SCIENCE

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THE INTERRELATIONS OF PURE AND APPLIED CHEMISTRY[1]

WITHIN the past fifty years there has been a revolution in civilized industries more far-reaching in its effects than the rise or fall of dynasties or the arbitrament of war. It is a quiet, peaceful revolution, so unobtrusive that even its active agents have rarely been aware of its significance. Even the astounding efficiency of armies in the present European war is but a minor item in the forward movement.

This revolution, which is still going on, and may continue indefinitely, is both simple and complex. It is merely the gradual substitution of scientific accuracy for empiricism, of quantitative and rational methods for rule of thumb. It means better service, better wares, intelligent agriculture, improved sanitation, the suppression of epidemics, and the prevention of waste. Through its agency the luxuries of a century ago have become almost necessities; travel has been made easier and cheaper; commerce is broadened; and all the nations of the earth are now brought together in a community of interests which is only interrupted temporarily by war. Even the horrors of war are somewhat mitigated by the beneficent activities of the Red Cross service, which owes much of its effectiveness to the discoveries of science; an effectiveness which would have been impossible in the days of our grandfathers. With the aid of modern inventions the powers not at war are now able to relieve much of the suffering due to war. Steam and the telegraph have made charity more prompt and

[1] Address before Section VII. of the Pan-American Scientific Congress, January 3, 1916.

effective; while antiseptics and anesthetics, the products of chemical research, have checked the spread of disease and relieved pain.

Throughout this revolution chemistry has played and is still playing an important part. It not only touches every branch of industry, but it also reaches out into other fields of knowledge and aids their development. The geologist demands chemical data; physiology is in great part chemical; astronomy makes use of chemical discoveries whenever it analyzes the spectrum of a nebula or star.

In these preliminary remarks, I have suggested only the applications of science to the "betterment of man's estate"; but suppose there had been no science to apply. Suppose that no inquisitive mortals had ever cared to study apparently useless things, or to ponder over those obscure relations which foreshadow the discovery of natural laws. Civilization would have advanced, doubtless; but so slowly that centuries or even millenniums of progress could hardly have placed us on the level of to-day. If our predecessors had only considered mere utility, the great inventions of chemistry and electricity would never have been made. These inventions were the outgrowth of investigations that were conducted without thought of practical uses, but were searchings after truth alone.

History is full of paradoxes; and so I must seem to contradict myself when I say that the beginnings of science, the germs from which it grew, were certainly utilitarian. Discoveries were made by accident; of metals, of medicines, of dyes, and, probably earlier still, of fire. Facts, useful to mankind, were slowly collected, and in time, by the crudest of mental processes, were roughly classified. Similar things were grouped together, simple relations were observed; and these were the raw material with which science, as we understand it, began. Arts were highly developed before true science became possible. To trace their advance from savagery to civilization is one of the functions of anthropology.

The science of chemistry deals primarily with transformations of matter. Perhaps the first of these to attract attention was the change of wood to charcoal, but such transformations were doubtless taken as a matter of course, and gave rise to no serious reasoning. With the ancient Greeks, however, and perhaps earlier in Egypt, India and Crete, the accumulations of empirical knowledge led to speculations, and philosophers began to consider the absolute nature of matter. The Greek speculations are well known, but they were speculations only and bore no useful fruit. It was only after systematic experimentation had supplied a real basis for reasoning that chemical theory became possible. The Greeks were acute philosophers, but experimental work was the province of artisans, and so fact and theory rarely came together.

Slowly, however, a body of chemical doctrines developed, largely esoteric, and known only to the initiated, who had very practical aims in view. They sought to discover medicines and poisons, to transmute base metals into gold, to find a universal solvent and the elixir of life. Through their efforts many useful compounds were brought to light, but the problems they sought to solve were unsolvable. Their discoveries were the by-products of their researches, not the main object of their desires. Their speculations led to experiments, and in this union of theory, even false theory, with practise, modern chemistry began. By slow degrees empiricism developed into scientific method, and as the field of knowledge was enlarged, valid generalizations, true stimulators of rational research, were framed.

The union of theory and practise, that is the keystone of modern chemistry. Theory coordinates and arranges; practise discovers, and each one helps the other. The concrete facts of science, taken only as facts, form a disorderly and unmanageable mob; good theory converts them into a disciplined army. A thousand isolated facts are not easily remembered, theory brings them all under one general expression, and the difficulty disappears. Empirical knowledge is an aggregation of facts; theory combines them into that systematic organization which we call science. Chaos gives way to order. Theory, moreover, not mere speculation, guides research into profitable paths and makes practise more surely fruitful. The self-styled "practical man," who affects to despise theory, is apt to go astray, and to waste his time in haphazard experimenting. The Patent Office is the graveyard of many such fruitless efforts.

Let me illustrate my meaning by a concrete example: In theorizing upon the nature of matter the Greek philosophers developed an atomic speculation which was the subject of controversy, of arguments pro and con, for more than twenty centuries. It was speculation only, and it led to no definite results, for it rested upon no adequate basis of experiment.

A little more than a century ago John Dalton proposed an atomic theory which had for its purpose the correlation and explanation of certain established relations. In this respect it differed from mere speculation about what might or ought to be; it was something more than an affair of words and syllogisms, and, furthermore, it assumed quantitative form. In Dalton's hands the theory led to the discovery of those fundamental constants of matter which we call the atomic weights, with which the physical properties of the chemical elements are intimately connected. It was a fruitful theory, capable of growth, and for a hundred years it has been the chief guide of chemical research.

In the first place the atomic theory gave us, or at least made possible, our system of chemical formulæ, by which the composition of compound substances can be clearly and easily expressed. A vast number of individual data were thus brought into order, and became manageable. With these formulæ equations could be constructed and chemical arithmetic was born. Nearly all chemical calculations, especially the calculation of analyses, rest upon the constants which Dalton discovered. As a labor-saving device the atomic theory has been of enormous value. Chemical operations are also made more exact and economical by the calculations which theory has rendered possible, and wastage is avoided.

But this is not all. From the main stem of the theory subordinate theories have branched, and the theory of valency is one of them. Chemical knowledge became still more systematic and orderly, and chemists were guided into profitable lines of research. For instance, the benzene ring of Kekulé, a conception which had at first only scientific interest, led to consequences of the highest practical significance. The whole development of coal-tar chemistry, for over fifty years, with its discoveries of dyestuffs, medicines and explosives, has been systematically guided by Kekulé's generalization. Theory and practise have worked together and to mutual advantage. Pure science and applied science have both been benefited.

Between pure chemistry and applied chemistry there is no sharp line of demarcation; both are phases of one science which can not be subdivided. The difference between them is one of point of view, of purpose, or of temperament on the part of the investigator. One chemist seeks for

truth, regardless of its possible utility; another strives to apply the truth to the material welfare of mankind. The truth comes first, however; its applications only follow. The great edifice of applied science rests upon foundations of pure research. The work of Gilbert, of Galvani, of Volta, of Faraday, preceded the electrical advances of to-day. The seemingly useless discoveries of one generation have made modern inventions possible. In every department of science this principle holds true, and in none more than in chemistry. A single fact, insignificant by itself, may be the final link in an important chain of evidence.

The uses of a discovery can not be foreseen. Aniline was useless for many years after its discovery, but its importance is much in evidence to-day. Bromine and iodine were chemical curiosities at first, but they had much to do with the development of photography; an art which came into existence years after the two elements were first made known. So-called rare metals, unimportant only thirty years ago, have now found applications and are commercially valuable. Tungsten and vanadium are used in hardening steel, and tungsten also forms the filaments of incandescent lights. Thorium is utilized in the Welsbach mantle, chromium and titanium have found new uses; and the list might be indefinitely extended. Discovery came first, utilization was always much later. Modern bacteriology grew out of a controversy between two chemists, Pasteur and Liebig, who held opposing views as to the nature of fermentation. They fought over principles, and the practical consequences of the final decision could hardly have been anticipated.

Every argument has two sides. If applied chemistry owes much to pure chemistry, it has given much in return. It has stimulated research and suggested new problems. An honest investigation in the field of applied science is likely to yield some data of no immediate use in industry, but nevertheless of real scientific interest. Such data are often more than isolated facts, for they may fill gaps in our knowledge, or serve as evidence in the establishment of some principle. The search for useful derivatives of coal-tar, for example, has led to the discovery of thousands of compounds which, although commercially unavailable, have yet helped to build up the colossal structure of organic chemistry. Theory has aided practise, and practise has done much to strengthen theory. Neither side can claim absolute supremacy.

In all that I have said so far there is nothing new, at least to men of scientific training. We all know the outlines of chemical history, and can agree in a general way as to fundamental principles. But knowing and realizing are two different things. We become so accustomed to objects immediately about us that we often fail to realize their presence unless they are constantly used. It is the same with principles and ideas. The work we are actually doing absorbs our thoughts, and we forget or unconsciously ignore the equal, perhaps greater importance of other things. We know but do not realize. The most obvious truths are those which oftenest need to be recalled. They are so obvious that they no longer attract attention. On occasions like this it is permissible to emphasize them, and truisms become respectable.

I speak now to experts; but what of the layman, the employer of labor, the consumer of scientific results? How far can he be made to realize that his applications of science rest, not upon empirical experimentation, but upon a long line of seemingly abstract researches, guided by theories which to him appear to be visionary?

To this question no general answer can

be given, and for obvious reasons. Some manufacturers are ignorant and stupid, the ultra-conservatives; others are intelligent, progressive, wide-awake. Great advances, however, have been made, and the good work still continues. The older men among us can remember the time when American mills and factories rarely employed a chemist, except when difficulties were encountered which could only be solved by analysis. Even then the cost of the work was paid most grudgingly as if it were an extravagance which should have been avoided. Now it is usual for manufacturing corporations to maintain laboratories, in which chemists, too often underpaid, are regularly employed. Some companies, the General Electric Company, for example, spend large sums of money on research, but others are more niggardly. Here we have much to learn from Germany. Her great advances in chemical industries have been made possible by the employment of trained investigators, whose duty it is to discover new products of value and to improve processes. Men who had shown ability in the solution of unsolved problems were chosen for this work, and not mere analysts only. In Germany, more than in any other country, has the commercial value of scientific intelligence been realized. The routine man has his place, but the thinker outranks him. When American employers are willing to spend as much time and money on research as they now spend on law, their economic conditions will be much improved. The chemist who solves an important problem, or who shows how to avoid waste, might well be paid as much as the lawyer, who, after all, may only lose his case. Although we are improving, we still have far to go.

A congress of this kind is of slight importance unless it can bring forth suggestions which shall help in the future advancement of science. It is, of course, pleasant to meet together, to compare notes and to form new friendships, but something more serious and permanent is demanded. What does science need, and what are its weak points? These are questions worth considering.

So far, with few exceptions, science has advanced through the efforts of individuals, and not by any definite system. The result is, especially in chemistry, an ill-balanced body of knowledge, overdeveloped in some directions, underdeveloped in others. The individual studies the subject which interests him and has attracted his attention, and too often fails to think of chemistry as a whole. Our knowledge is full of gaps, and these frequently occur where one would least expect to find them. We know many physical constants, for example, but for no single substance have all the desirable data been determined. This is a condition which should be remedied—but how?

The essential thing, it seems to me, is that there should be greater cooperation among investigators, and a subordination of personal interests to the general welfare. There are individual geniuses, of course, whose imagination reaches out into the unknown, and brings back wonderful discoveries; but such men must work alone and never in harness. They are the glorious few; I speak for the laborious many. Nor do I suggest any check to individual enterprise, only that it should be supplemented and helped by some intelligent system.

In every department of science there are problems too large for any single worker to handle, and here cooperation is possible. In this direction astronomers have set us an example, and observatories now combine their resources in mapping the starry heavens. Each observatory takes a definite zone, and the work goes on systematically. Such cooperation is practicable, and it leads to

permanent results. A definite field of work is definitely divided, and then cultivated under a preconcerted plan.

In chemistry, however, institutions equivalent to astronomical observatories can hardly be said to exist. Therefore, it is desirable that they should be created. Laboratories for systematic research are needed, in which bodies of trained men can work together for the common welfare. The work most needed to be done is not showy, but laborious; it will bring little fame to the individual, whose personal interests, however, need not be wholly disregarded.

To make my meaning clear I may cite one line of investigation which might be taken up, the importance of which I have discussed on several previous occasions. The great, fundamental problem which I have in mind is this: what relations connect the physical properties of compounds with those of their component elements? How can we calculate the one from the other?

The first thing to do, evidently, is to determine with accuracy the physical constants of the elements themselves; for just here our present knowledge is wretchedly incomplete. Take iron, or gold, or copper, for instance; how much do we know of their fundamental properties? A fraction only, a small fraction of what should be known. Here, then, is one line of work for an organized laboratory to do; one which would lay the foundations for great generalizations. Each constant should be measured throughout the entire range of attainable temperature; excepting only those which hold for one temperature alone. To accomplish all this new methods would have to be devised, and new instruments invented; and this would be of service to industrial enterprises as well as to science. The great revolution of which I spoke at first would be still farther advanced, precision would replace present uncertainty; all chemistry and all physics, the Siamese twins of science, would reap unforeseeable advantages.

A modern dreadnought costs, with its equipment, fifteen millions of dollars. It may be sunk by a torpedo in the first week of its career, or it may last twenty-five years, never meeting an enemy, and then be discarded as obsolete. The battleship is necessary, no doubt, at least as society is now organized; but it is unproductive, an instrument of destruction, and, therefore, perhaps unavoidably, a waste.

Fifteen millions of dollars! For one fifth of that sum a laboratory for research could be built, equipped and permanently endowed, which would benefit mankind for centuries to come. Surely some of the wealth which chemistry has created might well be devoted to such an enterprise as I am advocating now. Libraries, observatories and museums have all been enriched by private beneficence, but here is something of no less merit for which no provision has been made. Let us hope that the forward step may first be taken somewhere within the Western Hemisphere.

Between pure and applied science, or, rather, between the scientific investigator and the so-called "practical" man, there is often, but not always, an unfortunate difference. The worker in pure science publishes his discoveries to the world, regardless of commercial values. The manufacturer, on the other hand, who pays or thinks he pays for scientific investigations, is apt to keep his results secret, in order that he may turn them to personal profit. This policy of secrecy, too often followed, is bad for science and for industry. Science is deprived of useful data, which might add greatly to its advancement. Manufacturers waste their time and money in duplications of research, or, frequently, in rediscovering that which is already well

known. I have myself seen a supposedly "secret" process which had been in print for many years and was doubtless known to all competitors. Temporary secrecy, pending applications for patents, is of course not objectionable, but permanent secrecy is wrong. The man who uses science in developing his industry owes something to science in return. In the long run, moreover, publicity regarding scientific investigations is profitable. With a liberal policy, each manufacturer would give out his own small contributions to science, and receive the results obtained by all others in return. The practise of secrecy, to use the common phrase, is penny wise and pound foolish.

I plead, therefore, not only for cooperation in pure research, but also for greater cooperation, for more reciprocity between investigation and industry. The application of science to human welfare is glorious; its selfish uses are at least not praiseworthy. The devotee of pure science and the technologist should seek to understand each other, and to realize that the conduct of research involves mutual responsibilities. We may not attain to our ideals, but we can surely move towards them.

To-day the thoughts of the civilized world are turned towards war, and all men are longing for the peace which must come, sooner or later. As one of our earliest poets has said:

> War ends in peace, and morning light
> Mounts upon midnight's wing.

That is true of material warfare, but we are engaged in a conflict which, fortunately, can never end. It is the war of intelligence against the inertia of ignorance, and it keeps intelligence alive. Ignorance will always exist; the unknown will always be vaster than our knowledge, but we may hope for many future victories, and fear no ruinous defeats. So long as science lives it must move forward, driven by a splendid discontent with our deficiencies. May we never be satisfied, and forever advance, safe in the conviction that every conquest of ours over ignorance means the greater welfare of mankind.

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THEODOR BOVERI[1]

WITHIN a single year after Weismann's death our science has suffered another severe blow in the loss of Theodor Boveri, who died in Wuerzburg on October 15 at the age of fifty-three years. Pioneer and leader in the fields of cytology and experimental zoology, his loss will be felt keenly in this country where he had so many friends and pupils and where his field of research has been so popular during the past two decades. Boveri's personal life was very simple, always devoted to his work, his family and the pleasure coming from a deep love for art and nature. A native of Bavaria, he studied first philosophy and later zoology in Munich. His doctor's thesis on the structure of the nerve fibers in vertebrates treated a subject to which he did not later return. For, encouraged by his teacher, Richard Hertwig, soon after receiving his degree he entered the field of cytological research. Here, following the example of his teacher, he combined practically from the beginning the morphological and experimental methods.

His very first work in this line proved to be a great success, securing to him the *venia legendi* as privat dozent in the University of Munich. A few years later, when only thirty years of age, he was called to Wuerzburg, to succeed Semper in the chair of zoology and comparative anatomy. Here he remained during the rest of his life with the exception of frequent trips to the zoological stations of southern Europe, especially Naples, where he was a regular guest. He also made a short visit to the United States. His reputation as

[1] Paper read before the Biological Club, Yale University, December 3, 1915. I am greatly indebted to Professor Wesley R. Coe for kindly revising the manuscript.

an investigator soon attracted scores of students to the quiet laboratory in Wuerzburg, many of them coming from this country. One of the first, Miss O'Grady, of Vassar College, became his faithful wife, the mother of his daughter and an efficient assistant in all his later scientific work.

It is hardly necessary to add that with his growing fame came numerous honors conferred on him by his university, where he held the highest office as rector magnificus in 1909, by his government and by learned societies. Among the learned societies which conferred on him their membership is the American National Academy of Sciences.

When Weismann resigned his professorship in Freiburg Boveri was called to succeed him, but declined. Later the directorship of the new research laboratory of the Kaiser-Wilhelm-Gesellschaft in Berlin was offered to him. He first accepted, worked out the whole organization and brought together the staff; but suddenly he declined again. Possibly he already felt that his health was no longer vigorous enough for such a change. When I saw him for the last time, two years ago, in Naples, he gave me the impression of a strong and healthy man, but within a short time a disease of the gall-bladder forced him to interrupt his teaching for a year. An operation performed in the first days of October could not save his life.

When Boveri entered the field of biological research in the middle of the eighties the science of cytology was just outgrowing its childhood. Only ten years previously the fundaments had been laid. After certain incidental observations, especially by A. Schneider and Auerbach, Otto Buetschli collected his results on the division of the cell, the maturation and fertilization of the egg and the conjugation of Infusoria in his classic work of 1876. From that time dates the knowledge of the karyokinetic division of the cell with all its consequences. At about the same time appeared O. Hertwig's classic work on the fertilization of the sea-urchin egg, making it clear for the first time that fertilization is the union of egg- and sperm-nucleus. Then followed one fundamental discovery after another. Strasburger soon applied the new facts to the cells of plants. Flemming (1882) worked out the details of the mitotic figure, introduced the term "chromatin" and discovered the longitudinal splitting of the chromosomes. Roux (1883) realized the theoretical importance of the new discoveries and pointed out the meaning of the mitotic division of the cell, anticipating practically all of the views of to-day. In 1884 Heuser for plants and Van Beneden for animals were able to prove that the separated halves of the chromosomes are distributed to the daughter cells. (The word chromosome was first introduced in 1888 by Waldeyer.) At the same time Naegeli (1884) developed his ingenious theory of the idioplasm, and soon Strasburger, Koelliker, O. Hertwig, Weismann pointed to the chromosomes as the seat of the material basis of heredity. Only one important step was still lacking, the full understanding of the process of fertilization. Mark (1881) came very near to making this discovery, but it was Van Beneden (1884) who proved that in fertilization the same number of paternal and maternal chromosomes are handed over to the cleavage cells. These discoveries were made on the eggs of *Ascaris*, studied previously by A. Schneider and Nusbaum, and which have since become one of the classic objects of cytology. One after the other followed in those days the discoveries, which elucidated the whole process; the meaning of the polar bodies (Buetschli, O. Hertwig, Giard, Mark); the parallelism between ovogenesis and spermatogenesis (Van Beneden et Julin); the theory of the reduction division (Weismann); the behavior of the polar bodies in parthenogenesis (Blochmann, Weismann and Tshikawa); the continuity of the germ-plasm (Nusbaum, Weismann); the individuality of the chromosomes (Rabl); and finally, in 1887, the foundation of experimental cytology by O. and R. Hertwig. This was the year when Boveri's first "Zellstudien" appeared.

Under the influence of Van Beneden's classic book, Boveri began by studying the sex cells of *Ascaris*. In his Zellstudien, I., 1887, he

takes up the subject of the formation of the polar bodies. In harmony with Buetschli's discovery Schneider and Nusbaum had described the formation of the polar bodies in *Ascaris* as a regular mitosis, whereas Van Beneden and Carnoy insisted that it was a different process. Boveri proved that the former view is correct and was able to explain many discrepancies of these authors by discovering that there are two different varieties of *Ascaris* in regard to their number of chromosomes, called to-day univalens and bivalens. It is of interest to note that he expresses here the view that the recently discovered formation of a single polar body in parthenogenetic eggs may be explained by the assumption of a fertilization of the egg nucleus through the second polar nucleus. In 1888 appeared Boveri's Zellstudien II., dealing with the fertilization and division of the *Ascaris* egg. Here we find—besides many morphological details—his formulation of the theory of the individuality of the chromosomes, founded, as he freely recognized, by Rabl, and since one of the fundamental principles of cytological research. And he furnished important proofs by comparing the prophases of the division with the last telophases, and further by showing, that in cases of abnormal distribution of the chromosomes as many of them came out of the resting nucleus as had entered it. He was further especially interested in the mechanics of cell-division. He attributed a great importance to the special plasm surrounding the centrosome, the archoplasm (a theory abandoned later by him), and pointed to the importance of the continuity of the central bodies called by him centrosomes, already discovered by Van Beneden. And here we find developed also his idea, that the main importance of fertilization is the introduction of a centrosome into the egg. Starting from some abnormal cases, where a division of the cell is possible without a nucleus, he reached the conclusion that the centrosome is the dividing-organ of the cell. It is of importance to note that he emphasized even in this early paper (pp. 10–11) the necessity of experimental analysis of the phenomena of fertilization and heredity, recently inaugurated by the brothers O. and R. Hertwig.

To all these problems studied in *Ascaris* he furnishes a supplement in Zellstudien III., 1890, by applying the same studies on many marine invertebrates during a sojourn at Naples. For each of the objects investigated he could prove Van Beneden's law concerning the chromosomes in fertilization to be correct. Further he shows that in all these animals the reduced number of chromosomes is found even at the beginning of the maturation divisions in both sexes. The real reduction, therefore, must occur as early as in the oogonia and spermatogonia. It may be added here that during these years the complete parallelism of the cycle of male and female sex cells was definitely proven by the work of Van Beneden et Julin, Boveri, Platner and O. Hertwig, and that at the same time the problem of the reduction division was solved through Henking's idea of a conjugation of the chromosomes (the term introduced by Boveri), proved to be true by Rueckert (1891). As the final word of all his studies during these years may be regarded his article "Befruchtung" in Merkel und Bonnet's Jahresbericht, 1891, where he reviews the whole field in his keen and masterly way. It is of special importance that here were published the first figures of the process of diminution of the chromosomes, some years previously discovered by him in the cleavage cells of *Ascaris* and fully understood in its importance for the doctrine of the Keimplasma.

It has been stated already how keenly Boveri felt the necessity of applying experimental methods to the study of cytology. His first papers in this direction were published in 1888 and 1889. The latter especially gave a great impetus to our science, his famous report, "Ueber einen geschlechtlich erzeugten Organismus ohne muetterliche Eigenschaften."

The brothers Hertwig had succeeded in rearing fragmented eggs of Echinoderms up to the gastrula stage and had been able to fertilize enucleated fragments of sea-urchin eggs. Boveri conceived the very ingenious idea of using this method, to determine whether or

not the hereditary qualities are transmitted in the nucleus. He therefore fertilized enucleated egg-fragments of *Sphærechinus* with the sperm of *Echinus* and raised the resulting larvæ to the pluteus stage. He believed he was able to prove that these larvæ exhibited only paternal characters. It is well known that the validity of this conclusion was attacked by Morgan and by Seeliger. It was not until 1896 that Boveri published, in *Roux's Archiv,* the full account of this work and answered the objections of his critics. To-day we know from the work of many observers that the question is not a simple one. But in this paper we find incidentally another discovery, taken up by Boveri much later; namely, the dependence of the size of the larval nuclei upon the number of their chromosomes.

It is well known that during this first decade of Boveri's work our science was revolutionized. In the years 1884–88, Wilhelm Roux had laid the foundations of the science of Entwicklungsmechanik and the brothers Hertwig had started their experimental work in cytology and hybridization. Soon Driesch (1891) imbued the new science with his philosophical spirit, while J. Loeb (1891) attacked similar problems from a physiological point of view. Soon Morgan, Wilson and Herbst joined these pioneers and this line of work henceforth made itself felt also in all of Boveri's.

After some smaller papers, dealing with experiments relating to the theory of mitosis, he published in 1899 a full account of the facts relating to the diminution of the chromosomes, long since discovered by him.[2] To make all the facts clear he had to give a full account of the cell-lineage of this worm, a line of work of the greatest importance since the discoveries of Wilson and Conklin in the early nineties (although the foundations of this line of work date back to the investigations of Rabl, Van Beneden and Whitman, as is well known). The facts were in harmony with the results of Zur Strassen, which had in the meanwhile been published.

[2] "Die Entwicklung von *Ascaris megalocephala* mit besonderer Ruecksicht auf die Kernverhaeltnisse," Festschr. f. C. von Kupffer, 1899.

The year 1900 brought the fourth part of the Zellstudien, with the subtitle "Ueber die Natur der Centrosomen." The thirteen years which had passed since the publication of the first fascicle had seen an immense accumulation of morphological and physiological facts regarding the various parts of the cell, especially the chromosomes and the centrosomes. The importance of these latter for the mechanism of cell-division was already recognized by Buetschli as early as 1876, in spite of the fact that he did not realize them as distinct bodies. Flemming made this discovery, the significance of which was realized, however, only when Van Beneden and Boveri had discovered the life cycle of these bodies and recognized them as permanent organs of the cell, and after Boveri had pointed to their important bearing on the theory of fertilization. Since that time a vast accumulation of knowledge concerning the centrosomes had been acquired through the work of Brauer, Coe, Griffin, Haecker, Heidenhain, Kostanecky, Lillie, MacFarland, Mead, Meves, Van der Stricht, Vejdovsky, Wilson and others. Boveri now deals with all the questions which had been raised, adding a series of new facts about the life cycle of the centrosomes in different objects. He discusses the question of the nuclear origin of the centrosome in the male sex cells of *Ascaris,* discovered by Brauer and confirmed by Boveri's pupil Fuerst. Then came the question of the persistency of the centrosome in non-dividing cells according to Heidenhain, and the centrosome theory of the basal bodies of ciliary cells as developed by Henneguy and Lenhossek. Great importance was attributed to the question regarding the phylogeny of the centrosomes, discussed at this time in connection with the discoveries in Protozoa by Buetschli, R. Hertwig, Blochmann, Schaudinn and Calkins. Further he deals with the rôle of the centrosome in the mechanism of cell-division, which had been discussed broadly from a physical standpoint during these years by Buetschli, Heidenhain, Rabl, Ziegler and Rhumbler, and defends his old earlier viewpoint. Then he refuses Fischer's destructive criticism of the methods of microscopical re-

search; and finally tries to bring his views into accord with Morgan's discovery of the artificial astrospheres and Loeb's artificial parthenogenesis. Much space is devoted to the question concerning the relation of centrosome and centriole, a subject which is no longer considered of great importance. In connection with this paper may be mentioned his address before the Versammlung Deutscher Naturforscher und Aerzte 1901, "Das Problem der Befruchtung," where he again puts forward his centrosome theory of fertilization and endeavors to reconcile it with Wilson's new work upon the cytology of artificial parthenogenesis.

In 1903 Boveri published a preliminary report of his work upon multipolar mitosis, which investigation is, in the writer's opinion, the acme of his cytological work. Fol and O. Hertwig had discovered the simultaneous division of dispermic sea-urchin eggs into four cells. Driesch had separated these four blastomeres and raised stereoblastulæ from them. Boveri now uses this method for attempting to analyze the different qualities of the chromosomes in one cell. He demonstrated that the four cells derived from a tetraster-division may get every possible combination of the 3×18 available chromosomes; and that the distribution of normality or deficiency in the plutei raised from the isolated cells corresponds exactly to the probable content of the cells in regard to a complete or incomplete set of the qualitatively different chromosomes. These facts are to-day so well known to every biologist that they do not need to be exposed further. But it might be said that the full account of the work published in 1908 as Zellstudien VI., shows Boveri's analytical genius from its very best side; the reading of this work is a highly intellectual and esthetical pleasure. There may be incidentally mentioned here a short paper on the influence of the sperm on the larval characters of Echinids.[3] This paper based on hybridization experiments proves, contrary to the views of Driesch, that all larval characters are influenced by the sperm cell.

[3] Roux's Archiv, 16, 1903.

The same year Boveri reviews before the German Zoological Society the knowledge "Ueber die Constitution der chromatischen Kernsubstanz," a lecture that made a great impression on his hearers through his usual crystalline clearness and keen analysis. It is remarkable because he accepts here unreservedly the recently published hypothesis of McClung regarding the accessory chromosomes as sex-determiners; further, Suttons's analysis of the relation between the distribution of the chromosomes and Mendelian characters, a hypothesis which Boveri had conceived independently, but had not previously published, besides a brief remark pointing to his occupation with the subject. In this connection it might be said that it is characteristic of Boveri's work that important discoveries are mentioned in his papers occasionally, but not communicated *in extenso,* because he intended to work them out more fully later. So he always returns to his former observations after a great many years. Meanwhile there may have been done much work in the same line and ideas proposed from other sides, that he had himself in mind. And this often caused discussions about priority. So Boveri returned in 1905, in Zellstudien V., to his old discovery of 1889 that the size of nuclei in normal and merogonic larvæ of Echinids corresponds to the number of chromosomes they contain. The question of size relations between nucleus and cytoplasm had meanwhile become very important through the work of Gerassimoff (1902) and especially R. Hertwig (1903), who tried to base an analysis of many phenomena of cell-life on the assumption of a nuclear-plasmic relation. Boveri now had the ingenious idea of studying the relation between the number of chromosomes and nuclear and cell size by comparing the cells of Echinid larvæ experimentally produced with different chromosome numbers. There he had larvæ, called hemikaryotic, with the haploid number of chromosomes, obtained by artificial parthenogenesis (thelykaryotic) or by merogony (arrhenokaryotic); further, the normally fertilized, diploid or amphikaryotic larvæ, with the normal number of chromosomes, *i. e.,* twice

as many as the foregoing, then diplokaryotic larvæ, again with twice as many chromosomes as the last, produced by artificial suppression of the first cleavage figure. Now by comparing these larvæ he found that the surface of the nuclei is proportional to the number of chromosomes contained in them; that the size of the cell is again proportional to both; and that the number of the cells in the same stage is inversely proportional. It does not need to be said that he discussed all consequences from these facts, in their different aspects. It is well known that these discussions are still going on, especially in connection with the work of R. Hertwig and his pupils and of Conklin.

The ever-growing tree of cytological research had meanwhile developed another flourishing branch. Henking had discovered (1891) the facts about the accessory chromosomes without understanding their importance. The studies of Montgomery and Sutton again revived in the beginning of the century the interest in these facts. McClung recognized in 1902 their importance for the sex-problem, and the work of Miss Stevens and especially Wilson brought the most surprising clearness. Boveri immediately became interested in these questions and suggested to some of his students lines of work in that direction. In 1909 he reported before the "Physikalisch-medizinische Gesellschaft" in Wuerzburg, where practically all his discoveries were first communicated, Miss Boring's work, discovering the very important *Ascaris* type of sex-chromosomes; further about von Baehr's work, who cleared up simultaneously with Morgan the interesting behavior of the sex-chromosomes in the male cells of aphids; further about Gulick's studies on the sex-chromosome cycle of Strongylids, especially important because he was the first to work out in detail the conception that sex-linked characters are carried by the x-chromosome; finally Baltzer's work about sex-chromosomes in female Echinids (which later had to be revoked after Tennant's work). Boveri himself studied the sex-chromosomes in hermaphroditism (1911) and succeeded, simultaneously with Schleip, in bringing the facts in harmony with the general conceptions; the object was the nematode *Rhabditis nigrovenosa,* which shows an alternation between hermaphroditic and bi-sexual generations.

The last years of Boveri's life gave to us three more papers in the general field of cytology, each one showing him still at the summit of his intellectual strength. The first, "Ueber die Charaktere von Echinidenbastardlarven bei verschiedenem Mengenverhaeltnis muetterlicher und vaeterlicher Substauzen" (1914), gives a very fine analysis of the relative importance of protoplasm and nucleus in the inheritance of characters. By comparing hybrid larvæ with different qualities of both (developed from giant-eggs, fragmented eggs, isolated blastomeres) he reaches the conclusion that the chromosomes are responsible for the characters of the larvæ (in agreement with Baltzer and Herbst and opposed to Godlevski). In the second paper, "Zur Frage der Entstehung maligner Tumoren" (1914) we find Boveri in a field at first sight far distant from his usual line of work. But only apparently. In his former analysis of the chromosomes in multipolar spindles he had already pointed to the possibility of explaining the sudden origin of malignant tumors and their behavior by the assumption that they originate from cells with abnormal combinations of chromosomes resulting from an occasional multipolar mitosis produced by some influence in the surrounding medium. As he believes that this idea, very closely connected to von Hansemann's cancer-theory, might be useful for further research, he works it out here in extenso and discusses its merits in regard to the facts of pathology. The third paper finally, and the last one published by Boveri during the summer 1915, deals again with a subject, discussed by him 27 years before, namely, the origin of Siebold's famous gynandromorphic bees from the Eugster hive. Boveri was able to secure the original material and to work it through in order to determine whether his old hypotheis of 1888 or those of Morgan (1905) or Wheeler (1910) was correct. By means of a very beautiful analysis he shows that his

own hypothesis—fertilization of one nucleus after a premature division—is the only one in agreement with the facts.

It has already been said that Boveri's cytological work was always intermingled with studies in experimental embryology. His favorite objects, sea-urchin egg and *Ascaris* embryos urged him to work out problems in that line. There may be mentioned only two of his most successful pieces of work. One of these deals with the polarity of the sea-urchin egg. Selenka and Morgan were already acquainted with some of the facts, and the work of Roux, Driesch and Wilson had brought the discussion of egg-axes, regulation and equipotential systems, to the foreground. Boveri (1901) now is able to demonstrate morphologically the polarity of the sea-urchin egg—the well-known pigment ring—and to point out in a series of experiments how this preformed polarity explains all the previous results regarding the development of isolated blastomeres, fragmented eggs, deformed germs and larvæ with dislocated blastomeres.

The second series of experiments—partly done in connection with two of his students (Miss Stevens and Miss Hogue)—deals with the potency of the *Ascaris* blastomeres, studied especially with the centrifuging method and in cases of dispermia. His paper, "Die Potenzen der Ascarisblastomeren," in R. Hertwig's Festschrift, 1910, constitutes another high-water mark of his work. He mixes the plasmatic content of the eggs by centrifuging them and combines this in other cases with destroying one of the first blastomeres with ultraviolet rays. Then he follows with great accuracy the cell-lineage and reaches through a wonderful analysis the quite unexpected conclusion that in these eggs with strongly determinate cleavage nothing like organbildende Keimbezirke can be present, and that these eggs are very probably to be regarded as a "harmonious-equipotential system." In the same paper he gives an answer to another question, which had vexed him, since he first entered the field of cytology, namely, the cause of the diminution of the chromosomes in the somatic cells. By a most remarkable analysis he reaches the conclusion that the constitution of the protoplasmic surroundings is alone responsible for the process.

Besides all this closely correlated work, Boveri only once—with the exception of his doctor's thesis—entered a quite different field of research. The result was his paper on the nephridia of *Amphioxus,* one of the classics of vertebrate morphology (1892). His discovery of the protonephridia of that famous animal, as the result of logical thinking and consequent observation, is well known to every biologist as well as the phylogenetic significance attached to it. In his later years he returned but once to this subject, following Goodrich's discovery of the solenocytes, but always retained a special interest in all questions concerning the *Amphioxus,* encouraging also the work in this direction done by his assistant Zarnik.

The number of papers published by Theodor Boveri is comparatively small, only about forty. But of these there are very few which could be called unimportant, and a surprisingly large number of them constitute landmarks in the progress of our science. This is to be explained by his way of working and thinking. If his ability is to be characterized in a few words, one might say he was keen, philosophic and artistic. Keen, in that his piercing intellect immediately saw behind a minor observation its far-reaching consequences, and followed them patiently to the last detail. Philosophic, as he followed his discoveries and put them in their proper place within the science of biology with an exact logic, sometimes almost striving at dialectics, and with the spirit of clearness and order. And last, but not least, artistic. The construction of his ideas has an almost esthetical beauty. And at the same time he was a master of the language. If he talked before a learned society he succeeded, in spite of his calm, almost monotonous speech, to fascinate everybody, through the clearness and thoughtfulness of his words, as well as through the wonderfully refined diction. His papers are written in the same spirit; few scientific treatises have been better written. And where he

could devote himself especially to the esthetic side of a paper, as in his wonderful Rector's address, "Die Organismen als historische Wesen" or in his necrologue on Anton Dohrn, he reached the state of literary perfection of a work of art. And these characteristics of his work were in full harmony with his personality. At first sight not remarkable, he immediately fascinated one through his eyes, flashing with genius. And those who knew him were aware how much the artistic side of life meant for him, who was more than an amateur in music and painting. He was not only a great scholar, but a noble, harmonious man. What he has been for our science may be said with the words that he himself dedicated to Anton Dohrn:

> Er brauchte ja nur um sich zu blicken, um sich sagen zu muessen, dass er der Biologie einen Impuls gegeben hat, dem wenige sich an die Seite stellen können, und dass seine Tat und mit ihr sein Name leuchten werden in der Geschichte unserer Wissenschaft, weit hinaus, wo nur die hoechsten Gipfel noch sichtbar sind.

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ARTHUR WILLIAMS WRIGHT

Professor Arthur Williams Wright died at his home in New Haven, Conn., on December 19. He was born on September 8, 1836, in Lebanon, Conn., where his father, Jesse Wright, at one time a member of the Connecticut House of Representatives, served as justice of the peace, selectman and a member of the school board. Samuel Wright, who settled in Springfield, Mass., in 1639, was his earliest paternal ancestor in this country. His mother was Harriet, daughter of William Williams and a descendant of Robert Williams, who came to this country from England in 1637, settling at Roxbury, Mass.

He received his early education in his native town, preparing for college, under William Kinne, at Canterbury. His career as an undergraduate at Yale College was a distinguished one. He not only achieved notable successes as a scholar in mathematics and astronomy, his studies of predilection, and in Latin, but he was prominent in undergraduate social life. A life-long love for music naturally led him to identify himself with the musical organizations of his time, and a critical knowledge of music, including an enviable skill in performance, added largely to the pleasures of his later and more leisurely life.

After graduation he continued his studies at Yale, specializing in mathematics and science, and acquired the degree of Ph.D. in 1861. From this time until his retirement in 1906 his life was identified with Yale except for a period in 1868–9, when he studied at Heidelberg and at Berlin, and the three years 1869–71 during which he held a professorship of physics and chemistry at Williams College. In the last named year he returned to Yale as professor of molecular physics and chemistry.

One of Professor Wright's most distinguished services to his university, and indeed to the teaching of science in America, was the early recognition that the practise of combining professorships of physics and of chemistry had ceased to be either economical or possible. It was, therefore, under his stimulus and activity that the first Sloane Laboratory of Yale College, the first structure in the country devoted exclusively to the work of a physical laboratory in the modern sense—was designed and constructed. This was completed in 1883, and henceforth he devoted his time, until his final retirement, to instruction and various physical investigations there, although the title of his professorship was not changed to that of molecular physics until 1887. This Sloane Laboratory also contained the study and lecture room of Professor J. Willard Gibbs, whose contributions to physical sciences have made it celebrated for all time.

The greater portion of Professor Wright's scientific work found its first publication in the *American Journal of Science.* These contributions are not merely important; they are characterized by rare excellence of form and of clarity. A short review of these papers will prove of interest.

"On a Peculiar Form of the Discharge be-

tween the Poles of the Electrical Machine," Vol. 49, 1870. This paper describes the glow produced upon the positive ball in an active electrical machine and the conditions under which it may be produced. The striking fact that each portion of this luminous surface can be regarded as due to the effect of a point area on the negative ball, as proved by sharp geometric shadows formed by minute obstacles anywhere within the region between the conductors, is quite new and it affords a particularly beautiful method of determining the shape and position of the lines of force.

"A Description of a Simple Apparatus for the Production of Ozone," Vol. 4, 1872, was followed by two studies of the chemical action of ozone. The first of these, "On the Action of Ozone upon Vulcanized Caoutchouc," Vol. 4, 1872, calls attention to the cause of the deterioration of the insulating properties of vulcanite and gives means of correcting the fault. The second paper, "On the Oxidation of Alcohol and Ether by Ozone," Vol. 7, 1874, is an application of his ozone apparatus to the chemical investigation indicated in the title.

In the same year Professor Wright published two papers on the "Zodiacal Light" and a note on his observations concerning the polarization of the light of Coggia's Comet, all of which are contained in Vol. 8. In the first of these papers the question of the polarization of the zodiacal light even to a fair determination of the ratio of polarized light to unmodified light, seems to have been definitely settled by the skilful use of a polariscope of his own design. So, also, his second paper, on the spectrum of the zodiacal light, appears to have determined once for all a discussion which had occupied many observers.

In Vols. IX. to XII., we find a series of papers, five in all, of great interest on the gaseous contents of meteoric irons and stones. In the first of these papers he reviews the known results of the investigations upon the occluded gases of meteoric irons, quoting Professor Graham and Professor J. W. Mallett. In his own investigations the material came for the most part from the collection in the possession of Yale University. His conclusions in this first paper were that no one of the several irons which he studied gave any spectroscopic evidences of unknown elements. The second paper is a brief one upon the gases derived from the meteorite of February 12 of this year, presented as a note preliminary to a farther study.

In Volume X., "Examination of Gases from the Meteorite of February 12, 1875," Professor Wright gives a thorough review of the gaseous contents of this meteor. It appears to be the first stony meteor thus investigated and the results are of great importance; they not only show the presence of gases occluded in stony meteors but that they are distinguished by having oxides of carbon as their characteristic gases, instead of hydrogen. He points out the bearing of these observations upon the peculiar spectra of comets and as a support of the meteoric theory of comets.

In Volumes XI. and XII. Professor Wright continued these important investigations, extending them to a considerable number of stony meteors of known origin. The earlier conclusion that stony meteors are characterized by a large amount of occluded carbon compounds was abundantly verified, and the last paper contains a long discussion concerning the bearing of these observations on the current theory of comets.

This terminates the series of papers on occluded gases in meteorites, but it is interesting to note that the mastery of the problems involved served him in an admirable piece of work five years later, published in Vol. XXI., 1881. The paper "On the Gaseous Substances contained in the Smoky Quartz of Branchville, Conn.," is sufficiently defined by its title, but the skill and success with which the investigation was carried out and its results presented makes the article a model worthy of careful study.

In 1877 Professor Wright published two important papers, in Vols. XIII. and XIV., respectively, on the deposition of metallic films by the cathode discharge in exhausted tubes. A clear description of the technique of the process and of the physical properties of a large number of metals thus treated makes the

papers of unusual interest. The intrinsic value of his method has proved so great that it is quite probable that the name of the author is more widely known from these scientific contributions than from any others published during his long and active life.

In the foregoing review of the scientific work of Professor Wright there has been no effort to do more than sketch the contents of the papers of chief importance, a large number of notes and minor contributions to science have been ignored. It would hardly be just, however, to fail to note his activities in X-ray experiments. At a time when Röntgen's discovery was hardly more than a rumor and the greater number of physicists, perhaps somewhat skeptically, were awaiting more definite descriptions of methods and results, Professor Wright immediately applied the test of experiment and secured the first of these photographs made in this country. This showed in a very striking way his command of all the resources of his science at the time; nor did he stop with a mere verification of the most wonderful features of the phenomena. He made many studies of the nature of the radiations and their reactions on various forms of matter, but, like other contemporary investigations, the results were hardly more than negative and he did not publish them in a permanent form.

Professor Wright was a fellow of the Royal Astronomical Society of Great Britain and of the American Association for the Advancement of Science; he was a member of the American Physical Society, of the National Academy of Sciences and of other learned societies.

C. S. H.

THE LOUTREUIL FOUNDATION

It is stated in *Nature* that the first distribution of this fund under the auspices of the Paris Academy of Sciences has been made. The grants recommended fall into three classes:

1. To institutions specially mentioned in the will of the founder. The Natural History Museum, 1,000 francs for the continuation of researches on orchids undertaken by Professor J. Costantin, and 5,700 francs for the purchase of accumulators, and 4300 francs for a radiographic installation needed in the laboratory of Professor Jean Becquerel. The Collège de France, 4,000 francs to G. Gley, for the installation of an apparatus in his laboratory for the production of cold; 5,000 francs to L. Cayeux, for completing the equipment of his geological laboratory for petrographical researches; 2,400 francs to M. Müntz, director of the laboratory of vegetable chemistry of Meudon; 2,000 francs to L. Nattan-Larrier for the purchase of a centrifuge and incubator for cultures of microorganisms. As the provincial observatories are all attached to the universities which have already received a special legacy from M. Loutreuil, the council will only consider claims for grants relating to researches of a personal order. Under this head 3,000 francs is granted to M. Gonessiat, director of the Algiers Observatory, for the construction of an apparatus designed to measure the intensity of Hertzian waves and for a vertical seismograph. Polytechnic School, 3,000 francs to E. Carvallo, for the continuation of his researches on a method of shooting at airships. The veterinary schools of Lyons and Alfort, each 5,000 francs, for the upkeep of their libraries; the veterinary school of Toulouse, 3,000 francs for the same purpose, and 1,000 francs to M. Montane, for the reorganization of the anatomical collections of this school.

2. To institutions admitted by the president of the academy to participate in grants from the Loutreuil Fund. The Conservatoire des Arts et Metiers: 3,000 francs to Marcel Deprez, for his experiments relating to the transmission of the heat of gases to metallic walls, constantly cooled, and for experiments on electrical phenomena arising from internal-combustion motors; 4,500 francs to A. Job, for the purchase of a calorimetric bomb, an electric transformer, and other apparatus necessary to his researches on the velocities of oxidizing reactions; 6,000 francs to Jules Amar, for improving his equipment for the study of the muscular forces of man at work by the graphic and chronophotographic methods.

3. To other societies and to individuals. The Société de documentation bibliographique, 2,000 francs; 2,000 francs to Henri Piéron, for the equipment of his laboratory at the Sorbonne for physiological psychology; 2,400 francs to Louis Mengaud, professor at the Lycée of Toulouse, for exploratory work in the province of Santander; 10,000 francs to Charles Marie, for assistance in the publication of tables of physical constants; 3,000 francs to Camille Flammarion, for his private observatory at Juvisy; 4,000 francs to Emile Miège, for experiments at Rennes; 1,000 francs for the preparation of plates illustrating fossils collected by J. Couyat-Barthoux.

The total grants recommended amount to 82,300 francs, and this does not exhaust the sum available. During the war it has been impossible for all the investigators to carry on work already commenced or to undertake new researches, and other expenditure considered desirable by the council has been excluded by the terms of the legacy.

SCIENTIFIC NOTES AND NEWS

Ivan Pavlov, the eminent Russian physiologist, died at Petrograd at the age of sixty-seven years. In 1904 he was awarded the Nobel prize for medicine.

Sir William Turner, principal of Edinburgh University, distinguished as an anatomist, has died at the age of eighty-three years.

Dr. Elmer L. Corthell, of New York City, who has had charge of important work in bridge, railway, canal and harbor construction, has been elected president of the American Society of Civil Engineers.

Dr. L. D. Ricketts, president and general manager of the Canadian Consolidated Copper Company, has been elected president of the American Institute of Mining Engineers.

The Academy of Natural Sciences of Philadelphia has elected as correspondents the following named: William Bateson, Charles E. Barrois, Thomas C. Chamberlin, Carl Diener, Alfred C. Haddon, Wilhelm Ludwig Johannsen, Stanislas Meunier, Albrecht Penck, William Trelease and Samuel W. Williston.

Dr. Edward Bagnall Poulton, Hope professor of zoology at Oxford University, has been elected a foreign member of the Swedish Royal Academy of Science.

Dr. Albert Einstein, of Berlin, has been elected a corresponding member of the Göttingen Academy of Sciences in the section of mathematics and physics.

The gold medal of the Royal Astronomical Society has been presented to Dr. J. L. E. Dreyer, for his contributions to astronomical history and his catalogues of nebulæ.

A grant of $500 from the C. M. Warren Fund of the American Academy of Arts and Sciences has been made to Professor James F. Norris, of Vanderbilt University, for the study of factors which influence the valency of carbon.

C. A. McLendon, field pathologist of the South Carolina Experiment Station, has accepted a position as expert in cotton breeding with the Georgia State Board of Entomology, Atlanta, Ga.

Dr. Albert Ernest Jenks, professor of anthropology in the University of Minnesota, has returned after a leave of absence to study the question of mixed-blood Indians. Congress passed an act in 1907 allowing "mixed-blood Indians" on White Earth Reservation, Minnesota, to sell their lands. In time the government brought suit against citizens of Minnesota to set aside titles to certain lands, under the claim that the Indians who sold such lands were pure-blood Indians, instead of mixed-blood Indians. Dr. Jenks was called to attempt to settle the question of blood status by anthropometric methods. Of the nine court cases tried so far with anthropological evidence the court has held that the sellers in eight cases were mixed-blood Indians.

Dr. H. L. Shantz, of the Bureau of Plant Industry, delivered the annual address before the local chapters of Sigma Xi and Phi Beta Kappa at the University of Nebraska on the evening of February 12, 1916. The subject of the illustrated lecture was: "Water as a Factor in Plant Growth."

Professor Douglas W. Johnson, of Columbia University, on February 11 addressed the United States Naval War College at Newport, Rhode Island, on "Topographic Features of Europe as a Factor in the War."

At the regular monthly meeting of the Cosmos Club, Washington, Dr. Charles Wardell Stiles delivered an address on "Some Medical Aspects of the Race Question in the South, with Special Reference to the Hookworm."

Dr. Julius Nelson, professor of biology at Rutgers College and state biologist, died suddenly at his home in New Brunswick, N. J., on February 16, from pneumonia. He was born in Copenhagen, Denmark, in 1858. He was a graduate of Wisconsin University, and received the doctorate of philosophy from the Johns Hopkins University. Dr. Nelson had been a professor at Rutgers since 1888.

Dr. John Wyllie, appointed professor of medicine in the University of Edinburgh in 1900, in succession to Sir Thomas Grainger Stewart, and retired owing to ill health in November, 1914, died on January 27.

The death has occurred at Copenhagen of Dr. Friedrich Krügen, director of the astronomical observatory at Aarhus.

Dr. J. C. Moberg, professor of geology at Lund, has died at the age of sixty-one years.

The U. S. Civil Service Commission announces an examination on March 21, for fish pathologist, for men only, to fill a vacancy at $2,500 per annum, in the Bureau of Fisheries, Department of Commerce. The duties of the fish pathologist are primarily to investigate the nature and the effects of diseases of fish or shellfish, physiological or environmental conditions associated with the development of pathological phenomena, and the means of prevention or cure. The investigation of stream pollution is involved as well as the study of the physical, chemical and biological conditions that may be salutary or deleterious to fish. Competitors will not be assembled for examination, but will be rated on education, experience and publications or thesis. Graduation with a bachelor's degree from a course in a college or university of recognized standing, and in addition at least one year of post-graduate work or the equivalent in chemistry or biology, are prerequisites.

According to information received via Buenos Aires, the magnetic-survey vessel *Carnegie,* under the command of Captain J. P. Ault, arrived at South Georgia Island on January 12, having made magnetic observations daily since her departure from Lyttelton, New Zealand, on December 6. Icebergs were encountered on nine days during the trip. The *Carnegie* sailed again on January 14, in continuation of her circumnavigation of the region between the parallels 50° and 60° south.

We learn from *Nature* that there is now at the London Library a small but very interesting exhibit of early printed books on astronomy, from the collection of Mr. Gilbert R. Redgrave. Many of them are from the press of Erhard Ratdolt, whose fine work at Augsberg and Venice is so well known. There is a splendid copy of a "Kalendar" by Monteregio (otherwise Regiomontanus), in Italian, and an even finer one in Latin, both printed by Ratdolt at Venice in 1476—works now of great rarity. There is also a very rare folio tract by the same author, "Universis Bonarum Artium Studi," printed at Nuremberg in 1476. These appear to be in absolutely perfect condition. Among other fifteenth-century books mention may be made of a fine copy of Hyginus, "Poeticon Astronomicon," of 1487, as well as the less rare edition of 1448. The diagrams of eclipses, etc., are frequently colored—some by hand and some printed in colors. Two works of later date, but of special interest, are Galileo's "Istoria e dimostrabioni," of 1613, describing the newly discovered spots on the sun, and announcing the configurations of Jupiter's satellites, and his "Dialogo" on the Ptolemaic and Copernican systems, which occasioned his condemnation by the Inquisition. The only English book is a fine copy of the first edition of Newton's "Principia" (1687).

The determination of the amount of water flowing in the streams of the Rio Grande basin, which covers the greater part of New

Mexico, large areas in southern Colorado, and a considerable territory in Texas and old Mexico, is of unusual importance to that region, for most of it is an arid agricultural country, entirely dependent on its streams for irrigation. Water Supply Paper 388, just issued by the United States Geological Survey, contains records for 1914 of the discharge of the Rio Grande and its principal tributaries, together with that of Colorado River of Texas and Brazos River. Systematic study of run-off in the Rio Grande basin was begun by the federal government near Embudo, New Mexico, soon after the passage of the act of October 2, 1888, which authorized the organization of the irrigation survey under the direction of the United States Geological Survey. A camp of instruction for hydrographers was established near Embudo, and at this camp and the gaging station near by the methods of stream measurement now in general use were systemized. In the spring of 1889 additional stations were established on the Rio Grande near Del Norte, Colo., and El Paso, Tex. From this beginning the work of measuring the waters of the Rio Grande basin has been expanded until there are now 40 gaging stations on the Rio Grande and its tributaries, Colorado River of Texas and Brazos. The report contains not only all data concerning stream flow collected in the western Gulf of Mexico basin by the survey and cooperating parties but also records furnished by private individuals and corporations. All stations in New Mexico were maintained in cooperation with the state. The United States Reclamation Service furnished a large part of the money expended in the lower Pecos River valley and also rendered assistance in the Rio Colorado, Rio Hondo and Rio Taos drainage basins. The United States Forest Service and the Indian Office also aided in the collection of data.

The thirty-sixth Annual Report of the Director of the United States Geological Survey, just made public, emphasizes its scientific and economic activities. The survey investigations cover every branch of the mineral resources of a country whose mineral resources are the greatest in the world. The work of the survey is conducted under three scientific branches and includes three corresponding kinds of activity. Under the geologic branch, investigations are made concerning the mineral resources of the entire United States and Alaska, ranging from truly exploratory surveys of regions practically unknown to white men to the most detailed geologic examination of mining camps. Last year 76,000 square miles were thus geologically examined. Work of the survey that is even more of a pioneer type, however, is done by the topographic engineers, who have made surveys during the year in 30 states as well as in Alaska and Hawaii. The survey's topographic map is the base or mother map of the United States. The other scientific branch of the survey is that which conducts investigations of water resources, including the measurement of the volume of the important rivers of the country and their tributaries, as well as the study of underground water resources. Stream measurements are carried on from year to year, and the engineering data thus obtained are used in all kinds of hydraulic engineering, such as projects involving power, irrigation, drainage, and flood prevention. Another feature of the Geological Survey's work is the collection and publication of mineral statistics. Survey geologists are in correspondence with some 90,000 miners, mine operators, and mineral producers, whose output covers all the useful minerals, and the data thus obtained are published by the Survey in reports on seventy-five subjects. The total appropriation provided by Congress for the Geological Survey during the current year is approximately $1,500,000.

In the joint statement given out by the United States Geological Survey and the Bureau of the Mint the value of new gold added to the home supply from mills and smelters operating on domestic ores (including those of Alaska, the Philippines and Porto Rico) in 1915 was $98,891,100. This shows the substantial increase of $4,359,300 over the output of $94,531,800 in 1914, and was within $782,300

of the record production of $99,673,400 in 1909. The gold-mining industry was generally prosperous again in 1915, according to figures compiled by H. D. McCaskey, of the United States Geological Survey, from preliminary reports received from the mines. Estimates made from these figures, which represent ores sold or treated during the year, as distinguished from the metal actually produced, show that the output was even higher, and that it approached, if it did not actually pass, the $100,000,000 mark; but some of the ore and concentrates produced from the mines and mills can not be smelted until 1916, and the refined gold did not become available for consumption in 1915. An increase in the yield of gold is indicated by the mine returns from every important gold-mining state, and a decrease is reported only from Washington, while the output of Idaho remains the same. The principal increases were nearly $2,500,000 in Colorado, over $2,200,000 in California, over $1,100,000 in Alaska, over $800,000 in Montana, nearly $650,000 in Utah, over $480,000 in Nevada, and over $300,000 in New Mexico. Smaller increases were reported from Oregon, South Dakota and Arizona. California retained first rank in 1915, with an output of about $23,000,000, and was followed by Colorado, with over $22,000,000; Alaska, with nearly $17,000,000; Nevada, with nearly $12,000,000; South Dakota, with over $7,000,000; Montana, with nearly $5,000,000; Arizona, with over $4,000,000; Utah, with over $3,500,000; Oregon, with nearly $2,000,000; New Mexico, with nearly $1,500,000; and Idaho and the Philippines, with about $1,200,000 each.

Preliminary estimates of the total yield of petroleum for 1915 indicate a slight increase over the record-breaking yield in 1914. This condition does not agree with the currently reported reason for the exceptionally high prices now prevailing for motor fuel. As a result of the over-load put on the transporting and refining phases of the petroleum industry by the excess output of crude petroleum in 1914, the year 1915 may be characterized as a period of readjustment in which production activity was purposely retarded as far as practicable. The small increase therefore is more significant than the simple figures suggest. According to John D. Northrop, of the United States Geological Survey, the marketed production of petroleum in the United States in 1915 approximated 267,400,000 barrels, and the total yield approximated 291,400,000 barrels, about 24,000,000 barrels of oil brought to the surface during the year being placed in field storage by the producers. The following table shows by states the marketed production of petroleum in 1914 and an estimate of the corresponding production in 1915, in barrels:

States	1914	1915
California	99,775,327	89,000,000
Oklahoma	73,631,724	80,000,000
Texas	20,068,184	26,000,000
Illinois	21,919,749	18,500,000
Louisiana	14,309,435	18,500,000
West Virginia	9,680,033	9,000,000
Pennsylvania	8,170,335	8,700,000
Ohio	8,536,352	7,900,000
Wyoming	3,560,375	4,200,000
Kansas	3,103,585	3,000,000
Indiana	1,335,456	1,000,000
New York	938,974	900,000
Kentucky	502,441	450,000
Colorado	222,773	200,000
Other states	7,792	50,000
	265,762,535	267,400,000

Secretary of Commerce Redfield has addressed to the Secretary of the Navy the following letter relative to the success of the Bureau of Standards in developing a radio-direction finder.

Recent quotations in the press from your letter to the Senate Committee on Naval Affairs give part of a report from Admiral Fletcher in which it is said that among the needs of the navy is a radio-direction finder. The Bureau of Standards has been investigating this subject for some time and has developed an instrument which is simple and practical and at the same time very efficient in operation. It indicates the direction of the source at the same time that the messages are being received, and while it is very sensitive to radiations in a given direction it is less affected by atmospheric disturbances and interfering radiations from other directions than an ordinary receiving apparatus. We have received messages by one or another of the three sizes of instru-

ments that have been built from Philadelphia, Boston, Glace Bay, Newcastle (N. B.), New York, Norfolk, New Orleans, Panama, Key West, San Diego and Hanover, Germany. When atmospheric disturbances have been very pronounced on the large antenna at the West Laboratory, they have been very slight on the direction finder apparatus, which is entirely indoors, having no antenna or earth or other outside connection. This apparatus appears to be well adapted to use (*a*) on merchant and naval ships to obtain the direction from any lighthouses or lightships that may be equipped with radio fog signaling apparatus, (*b*) to obtain the direction of one ship from another at sea, (*c*) to communicate between ships or ship and shore stations irrespective of direction by reducing interference and atmospherics, (*d*) to use by the War Department in field service, as the receiving apparatus is portable and requires no ground or antenna, and can be carried readily in a light vehicle or even by a single observer, (*e*) to use by the Coast Guard Service to receive distress signals and locate the direction, (*f*) for use by the Bureau of Navigation to locate amateur or other stations that are not observing the radio regulations or are otherwise interfering with radiotransmission of the government or legitimate commercial business. The Bureau of Standards is prepared to demonstrate the apparatus to representatives of the War and Navy Departments or other interested departments at any time desired.

UNIVERSITY AND EDUCATIONAL NEWS

An anonymous gift of $10,000 for surgical research at Columbia University has been announced by the trustees.

Morse Hall, erected in 1890 and containing Cornell University's valuable chemical laboratories and scientific equipment, was destroyed by fire on February 13. The loss is estimated at $300,000, partly covered by insurance. The cause of the fire has not been determined.

The board of trustees of the Ohio State University have ratified the proposal made by President W. O. Thompson for the establishment and maintenance of research professorships. The plan provides that men of recognized ability may be relieved from teaching to devote their entire time to scientific research.

Dr. Gorham Bacon has tendered his resignation as professor of otology in the College of Physicians and Surgeons, Columbia University, to take effect at the close of the present academic year.

To fill the vacancy caused by the resignation of Dr. William J. Means, dean of the College of Medicine of the Ohio State University, Dr. Eugene F. McCampbell, secretary of the state board of health, has been appointed to the deanship.

Dr. Waldemar Schleipp, associate professor of zoology at Freiberg, has been called to the chair of comparative anatomy at Würzburg, vacant by the death of Th. Boveri.

DISCUSSION AND CORRESPONDENCE

SCHOOL AND THE LONG VACATION

There is a widespread belief shared by those working in the pedagogic field and those on the outside that something is radically wrong with our educational methods. The results achieved in schools and colleges are in no way proportionate to the native intelligence, the expenditure of effort in teaching and the stupendous outlay of money represented by material equipment and cost of maintenance. Employers of labor in stores, shops and factories complain of the lack of training and efficiency in the young men and women available for hire, and college teachers of sound judgment seem quite generally convinced that the average student at the end of his four-years' course has not enough to show in cultural attainments and useful knowledge. As I have intimated, this disappointing result is not due to lack of ability on the part of the American youth, who for quickness of perception and capacity of learning are not outclassed by the youth of any nation. The fault lies elsewhere. It would carry me too far from my present purpose were I to enter upon a discussion of all the defects of our system. I intend dealing with one only, a definite concrete condition easily comprehended and fully remediable if once educators are impressed with its significance.

The fault I have in mind has to do with the long summer vacation. In my opinion this is placed in an entirely false relation to the school year. Long-established custom has fixed it in elementary and secondary schools, in colleges and universities between two separate and independent school years. The student finishes a course and drops books and habits of study for a period varying from two to nearly four months. At the end of the vacation he returns to a new class, to new teachers, to new studies. It takes him a considerable time—in the professional schools of a university, as I know from my own classes, from a week to ten days—until he gets properly oriented, which still further increases the unused hiatus.

I am not criticizing the length of the vacation. In our climate it is almost a necessity for teacher and student to have surcease from school work during the long heated term; but I believe the vacation is wrongly placed. It ought to come within the school year, not at its close. In its present position there can be no work assigned, for, speaking generally, the teachers of the completed year have no control over the student in the year he will begin in the autumn. If a student is industrious he may carry on work in the continued branches, but will do and can do little or nothing as regards new studies—Greek, higher mathematics, physiology or what not—in the mysteries of which he has not yet been inducted. The loss in momentum and direction is tremendous, and if we add it up for all the vacations during school life from the first year to graduation from the university this potential loss becomes vast and staggering.

What is the remedy? There are two; one is the all-year-round school such as is in vogue in the University of Chicago, with its four trimesters. In the South and the mid-Atlantic region, a summer trimester is almost out of question. It would, for example, be well-nigh impossible to keep all the departments of a university in full swing during July, August and September. There is another remedy, and that I want now to propose. I would not do away with the long vacation, but I would place it in the mid-period of the school term, by making the scholastic year begin in February or March instead of in September. The school year would end in February with promotions and graduations and a new year would begin after a brief recess of not more than ten days or a fortnight. The student would remain in the new class for at least three months before the summer holiday, more than enough for a good start. The long vacation might then be utilized for valuable and purposive study, partly assigned, partly optional.

I am aware of the existence of a certain pedagogic prejudice against burdening children with school work during the long vacation. What I am advocating is not the projection of the school year with its tasks and mental circumscription into the vacation, for I myself believe that one of the advantages of our long recess is that it gives the child's individuality a chance to develop. I maintain, however, that the assigning of a small amount of work does not interfere with the child's freedom. In the lower grades a very small amount suffices to keep up an interest and to preserve a continuity of thought, which is all that we need strive for. In the case of older pupils and certainly of college students we could well ask not merely the preservation of the mental *status quo* but enough work, proportionate to the length of the vacation, to carry the student a little beyond where he left off—and this again without materially infringing on our youth's traditional claim to a carefree holiday. When student and teacher meet in the fall, work could commence at once with the accumulated energy resulting from a sane combination of work and play during the summer. There would be no loss, but instead a great gain in momentum. Consider the totality of gain in the period from the first grade until the close of the four years' college course, a matter of fourteen or sixteen years.

The change I have suggested is applicable to all schools, elementary, high school, college and university, and can be brought about without doing any violence to the fundamental principles of our educational system. I know of no other reform comparable to this in prac-

tical feasibility that promises such great results.

David Riesman

University of Pennsylvania

A PLAN FOR COOPERATION AMONG THE SMALLER BIOLOGICAL LABORATORIES

Second thought is hardly necessary for a realization of the fact that the scientific laboratories of the smaller colleges throughout the country suffer greatly from their isolation, from the overworked condition of the instructor, and from the indifferent quality of the materials for daily use in the ordinary courses in zoology, botany or general biology. Such conditions, furthermore, have a habit of continuing thus unchanged throughout the years, much to the vexation of the instructor as well as to the detriment of the many students, in the aggregate, who take the various courses.

Although the complexity and expense of thorough laboratory equipment are both unlimited, it is yet evident that the prime desiderata for the giving of the ordinary courses to undergraduates are fairly simple matters—a good culture showing large *Amœba proteus* in abundance, prepared slides stained so as to show mitosis plainly under a dry objective, and other similar items of equipment are matters simple to mention but far from being satisfactorily provided even in some of the better laboratories.

Some further conditions confronting the biologist in the smaller laboratory may be summarized as follows: The task of providing a set of slides satisfactory for illustrating the organology and histology of the earthworm is not so difficult a matter in itself but, when taken in connection with the preparation of many other needed series, it is obviously out of the question that the work be done thoroughly well. The result is either equipment good in quality but scanty in amount or, if the supply be adequate, the quality is low. At this point it is perhaps worthy of remark that the provision of class and demonstration materials for the use of elementary students requires a special talent of the preparator. The lack of special scientific insight characteristic of the average student makes necessary preparations as plain as to detail as they are lacking in special bias.

As a possible method for providing some of this equipment satisfactorily and from the scientist's, rather than from the dealer's, point of view it has many times occurred to us that a system of mutual aid among a league of the smaller laboratories might be established which would not only furnish a system of exchanges of material valuable for teaching and research purposes but which might also be conducive to scientific and educational benefits as well. The writer feels certain that many of the difficulties outlined above would be relieved by the method to be proposed, which, briefly stated, is as follows: For each of a number of laboratories to specialize upon the preparation of a different element of equipment as, for example, the culturing of protozoa or algæ, the collection and proper preservation of certain other available materials and, in particular, the preparation of histological or cytological slides high in value for the demonstration of general principles. A division of labor thus affected, special pains might be taken for the collection, fixation and staining of material of a definite sort in order that the very best results might be secured and in a field for which the special training of the biologist or the special development of his laboratory might reasonably be expected to add value to the product. The method once mastered the mechanical details of indefinitely repeating the process and so providing a supply for others at work upon other tasks might be carried on by almost any undergraduate assistant.

Concentration of effort upon a task of this sort might easily result in a surprisingly high quality of a certain preparation even from a laboratory of small size and very modest equipment, and conversely the returns from the establishment of the system in benefits from other institutions might safely be depended upon to steadily affect a marked improvement in the quality of the courses offered.

Geographical advantages might also be de-

pended upon to enhance the value of the factor of equipment undertaken by any certain laboratory.

A definite statement of the objects to be sought as well as regulation of the various activities would, of course, be necessary, as well as the establishment of a basis of values and rules governing exchanges of materials which might or might not be for monetary considerations. The establishment of such regulations could well be placed in the hands of a secretary or committee of the parties to the agreement.

J. P. Givler

Southwestern College,
Winfield, Kans.

SCIENTIFIC BOOKS

A Revision of the Cestode Family Proteocephalidæ. By George Roger LaRue. (Contributions from the Zoological Laboratory of Illinois, No. 33.)

The graduate school of the University of Illinois is to be congratulated on the publication of this monograph, which, we are informed, is a "Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy."

Dr. LaRue has, in this thesis, made a contribution to the literature of helminthology of a kind that is much needed. He has performed the drudgery of examining the literature of his subject with skill and patience and at the same time has achieved noteworthy success in bringing order out of confusion. The labor of identifying species by future investigators should be much lightened on account of this contribution.

The monograph is a large volume of 350 pages and 16 plates containing 199 figures. The figures are simple line drawings, largely diagrammatic, but, so far as the writer has tested them, clear in diagnostic features and free from confusing or unnecessary details. Methods of technic are incorporated in the introduction, which should be of value to prospective workers on the anatomy of the cestodes. Hematoxylin mixtures are found to yield more satisfactory results than carmine. "It is noteworthy that the carmine stains give beautiful preparations of trematodes in toto, but fail almost entirely for cestodes. For the cestodes these stains fail because they do not sharply and clearly outline the sexual organs as they do in the trematodes, though not better than do the hematoxylins. In the judgment of the writer the use of carmine stains in cestode material has been responsible for many errors in the interpretation of cestode structures." An important introductory section deals with the anatomy and histology of the Proteocephalids. In this section the literature of this phase is reviewed critically. It is interesting to note that while insisting that the anatomy and finer structure of the internal organs furnish the most valuable characters for diagnostic purposes, the author remarks that more value should be given than is given to data as regards the host, the locality and habitat of the host, which data are always of value.

The insertion of a key to the better known genera and species of Proteocephalidæ is to be highly commended. The literature of the Cestoda is much scattered and there is need of synopses and keys if acquaintance with the distribution of species with all that goes along with that knowledge is to be extended and made accurate.

The bulk of the monograph is made up of the description of species of Proteocephalids, of which there are 33 from fishes and 18 from amphibians and reptiles. These descriptions are, from the nature of the case, of unequal proportions. For example, *Proteocephalus filicollis* (Rudolphi) and *P. torulosus* (Bartsch), neither found in this country, are given about eleven pages each. Extracts are made from French and German authorities and from the Latin of Rudolphi. There is perhaps justification in these instances for inserting descriptions in the languages in which they were originally written, although as a general practise the reviewer would advise against it. LaRue has not been content with simply reviewing the literature of such species as those just mentioned, but has studied material obtained from European helminthologists, and, having had the use of Dr. Ward's extensive collection, has been able to review the literature with an intelligence and authority that inspires confi-

dence in the reader. Other species, as, for example, *P. cyclops* (von Linstow), *P. nemetosoma* (Leidy) and *P. salvelina* (Linton), are given less space, such being, as a rule, records of material that either did not admit of certain identification, or at least were inadequately described. Such species as *P. ambloplites* (Leidy) and *P. perplexus* (LaRue), which are American species and have been studied by the author, are described in detail, and with such discrimination that there should not be any confusion in future identifications of these forms. Comparative tables of selected characters of Proteocephalid species are given. Such tables are of peculiar value in the identification of such soft-bodied forms as cestodes and trematodes, whose superficial appearance is affected diversely by preserving fluids. Under distribution it is of interest to note that amphibian Proteocephalids are known only from the two continents, North America and Australia, while those of reptiles and fish are known from all the continents.

The following conclusions are of general interest:

1. A species of *Proteocephalus* may occur in different host species of the same genus. Five species are limited exclusively to various species within the same host genus.

2. A species may occur in the different genera of the same family.

3. A species may occur in the members of closely allied genera, *i. e.*, of the same order. Four cases are known.

4. A species may occur in families of very wide relationship, *i. e.*, of different orders. There are two cases, of which one is doubtful.

A further general statement is: The parasitic infestation of the host is determined by the food eaten.

A suggestive fact, pointing to a wide and fruitful field of investigation, is indicated when it is noted that in this monograph of 350 pages less than 2 are devoted to the life histories of the Proteocephalidæ, and these pages are largely taken up with a discussion of probable life histories.

As to the relationship of the Proteocephalids to other cestodes, the author finds that structurally they are to be considered as being closely allied to the Tetraphyllidæ, while their relationship to the Cyclophyllidæ is distant. The inclusion and long retention of the Proteocephalids in the great genus *Tænia* was due to external features alone.

The origin of the Proteocephalids is discussed and the suggestion made that it may have been some member of the family Lepisosteidæ that is responsible for the introduction of these cestodes into the fresh-water environment.

A bibliography of 78 authors and 144 titles is appended. These range in time from 1766 to 1912.

Edwin Linton
Washington and Jefferson College,
Washington, Pa.,
January 22, 1916

SCIENTIFIC JOURNALS AND ARTICLES

The opening (January) number of Vol. 17 of the *Transactions of the American Mathematical Society* contains the following papers:

W. F. Osgood: "On functions of several complex variables."

E. B. Van Vleck and F. H'Doubler: "A study of certain functional equations for the θ-functions."

B. A. Bernstein: "A set of four independent postulates for Boolean algebras."

L. P. Eisenhart: "Transformations of surfaces Ω (second memoir)."

E. J. Moulton: "On figures of equilibrium of a rotating compressible fluid mass; certain negative results."

The February number (Vol. 22, No. 5) of the *Bulletin of the American Mathematical Society* contains: Report of the ninth regular meeting of the Southwestern Section, by O. D. Kellogg; "A note on the problem of Lagrange in the calculus of variations," by G. A. Bliss; "Concerning a non-metrical pseudo-archimedean axiom," by R. L. Moore; "A type of singular points for a transformation of three variables," by W. V. Lovitt; Review of Goldenring's Die elementargeometrischen Konstruktionen des regelmässigen Siebzehnecks, by R. C. Archibald; "Shorter Notices;" Wentworth and Smith's Plane Trigonometry and Tables

and Horsburgh's Modern Instruments and Methods of Calculation, by C. C. Grove; Longley's Tables and Formulas, revised edition, by Joseph Lipka; Enriques' Vorlesungen über projektive Geometrie, second German edition, by A. Emch; Miller's Descriptive Geometry, Armstrong's Descriptive Geometry, and Grossmann's Darstellende Geometrie, by Virgil Snyder; "Notes;" and "New Publications."

SPECIAL ARTICLES

AN APPARENT LATERAL REACTION BETWEEN IDENTICAL PENCILS OF LIGHT WAVES, CROSSING EACH OTHER AT A SMALL ANGLE[1]

1. *Methods.*—To exchange the component beams in the interferometer, to mutually replace the two pencils which interfere, is not an unusual desideratum. To replace two pencils of component rays travelling more or less parallel to each other, by pencils more or less normal to each other, to be able to operate at the point of intersection of corresponding pencils of rays from the same source, crossing at any angle, may be of interest in a variety of operations and may even suggest novel experiments.

In Fig. 1, I have sketched one of many forms of apparatus of the kind in question, with which I have recently been working. A beam of parallel rays from a collimator, *L*, impinges on the reflecting plate grating *G*. The diffracted pencils *a*, *b*, are reflected by the opaque mirrors *n* and *m* into *b′* and *a′*, to be again reflected by the opaque mirrors *M* and *N* into the pencils *b″* and *a″*. These impinge on the plate grating *G′*, so placed that both pencils are diffracted along the same direction *G′T*, into the telescope at *T*.

If now the opaque mirrors *m*, *n*, *M*, *N*, are appropriately rotated, the parallel component beams *GmMG′* and *GnNG′* may be replaced by *GmNG′* and *GnMG′*, respectively, which cross each other at *c*, while the pencils impinging at *G′* have been exchanged.

There is an essential difference in these two cases. Whereas in the case of parallel rays, *a′*, and *b′*, the double diffraction is an increment of either, in the case of the crossed rays, *a* and *b*, it is a decrement and the system tends to become achromatic. In the latter case one should suppose that homogeneous light and a wide slit only could be used in the interferometer. But this is not so.

2. *Results.*—The reflecting gratings with large dispersion constants in my possession waste too much light and the work is thus burdensome. The following results were therefore investigated with a good ruled transmitting grating, adjusted to secure the double diffraction of Fig. 1 in a single grating. This simplifies the method and the interferences are much more expeditiously found. The rays in such an apparatus must cross in the glass plate of the grating at *c*.

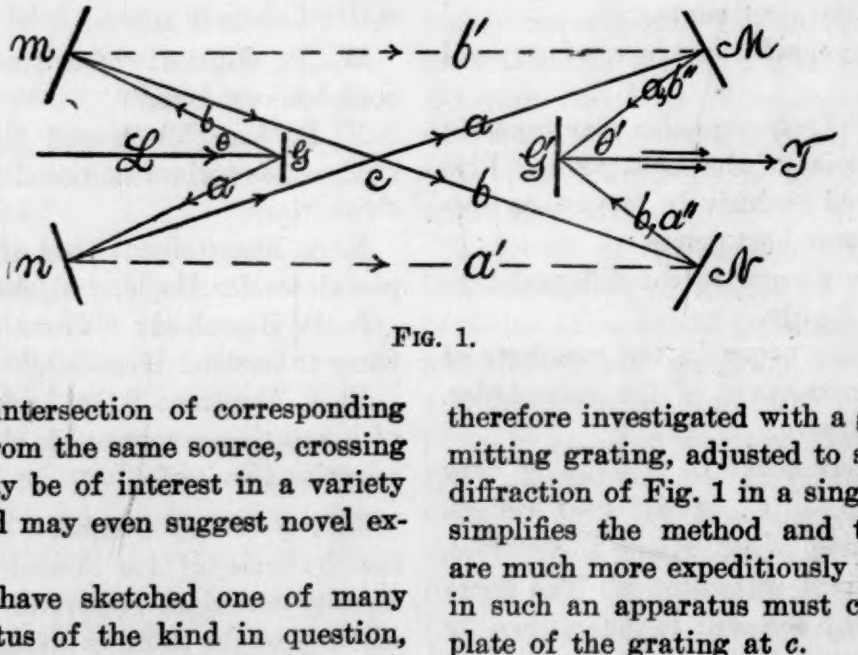

Fig. 1.

In the case of parallel rays *Nn*, *Mm*, white light and a fine slit, I obtained the linear phenomena of reversed spectra as usual. On using homogeneous light and a wide slit superb interferometer fringes were obtained. In every instance these are parallel striations crossing the whole field *uniformly*. They may easily be made coarser or finer, or rotated at pleasure, but a given field never shows independent groups; *i. e.*, there is no second periodicity

[1] Work done on a grant from the Carnegie Institution of Washington, D. C.

distinct from the first. In the case of crossed rays mN and nM, however, a uniformly striated field is only incidental. There is always a second periodicity present, distinct from the first, even if concealed. The striations are grouped in parallel strands. It is now quite possible to obtain the linear phenomenon with a wide slit and the occurrences, when homogeneous light and the wide slit are used, are merely a rhythmic reproduction of the linear phenomenon, parallel to the slit; *i. e.*, transverse to the spectrum.

To make this clearer, suppose the original or regular striations are vertical and that sodium light is used. Then the typical pattern is of the kind shown in Fig. 2*a*. It looks like a parallel set of thick twisted cords, hung side by side and equidistant. It is often much more complicated, though adhering to this de-

a *b* *c*

FIG. 2.

sign. The evolution of this pattern is obtainable on moving one of the slit images in the field in different amounts micrometrically over the other, keeping the longitudinal axes of the spectra in coincidence. Then if the fringes are originally nearly vertical apparently uniform striations, figure 2*b*, they change by rotation into the form figure 2*c*, and at the same time enlarge. In other words, the lines *b* consist of individual parts, behaving similarly but independently, as if they were a set of magnetic needles. The same results may be obtained with the single strand of the linear phenomenon and white light and here the rotation may be carried through nearly 180°, between infinitely small sizes. It is fairly tumbling in its mobility when of maximum size and horizontal. Again, suppose the original regular fringes to have been horizontal and apparently uniform. Then if the phenomenon is made of maximum coarseness (there are two positions of the grating for which this occurs), on slightly passing one slit image of the other, to different degrees, micrometrically, the ap-

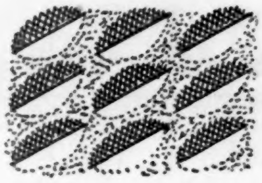

FIG. 3.

pearance presented is given in Fig. 3. The fringes have become nodules, half black and half brilliant, strung transversely like bean-shaped beads on parallel strings and hung vertically against a neutral (non-interfering) yellow background of sodium light. In incidental cases the black shadows may be a line, and the field is then an apparently uniform coarse grid; but generally they are separated as in Fig. 3. Sometimes the central strand is strongest and the intensity diminishes on the right and the left. More frequently the two central strands are equally strong. Five or six strands may be present. On moving the mirror M parallel to itself, these strands move to right or to left as a whole, in accordance with the equations of displacement interferometry. In fact, in view of the individuality of the strands, the apparatus is a useful displacement interferometer.

The occurrence of these parallel strands for crossed rays and homogeneous light is difficult to explain. I have tried a great variety of things (slightly wedge-shaped compensators and other methods of superposing special interferences, etc.) to produce them with parallel rays mM and nN, or to break them with crossed rays mN and nM, without avail. There is no focal plane effect, nor any polarization effect. It is therefore necessary to confront the case, at its face value, as in Fig. 4. Here S and S' are the traces of two vertical, longitudinally coincident, reversed spectra, drawn apart for distinction, the region of the D lines only being used. The light is homogeneous to this extent and the slit wide, so that there is oblique incidence. Then every point of S should (on adjustment) interfere with every point of S', the result showing as a

uniformly striated field in the telescope. This is emphatically the case for the parallel rays, b' and a'; but with the crossed rays a and b

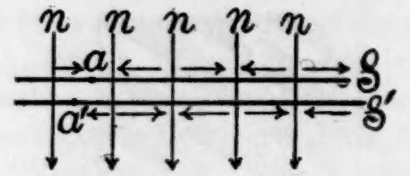

Fig. 4.

the interference is confined to the rays in the equidistant positions, n, in Fig. 4, and midway between them the field is a neutral yellow. In other words between the rays n, the rays are displaced laterally as shown by the arrows (recalling the arrangement of nodes in acoustics), so that corresponding rays a and a' for instance, do not coincide and hence can not interfere, the region aa' (Fig. 4) remaining neutral. In Fig. 5, the rays crossing at a vanishing angle have been shown for three ray filaments and the transverse arrows indicate the directions in which the rays have been urged, laterally. Naturally I am merely stating the case as suggested by the results.

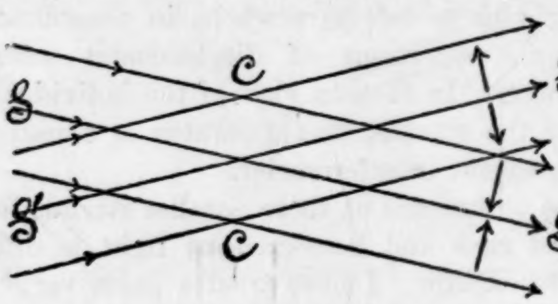

Fig. 5.

One may argue that there may be a secondary periodicity in the grating. But why does it not appear at all in the case of parallel pencils, when it is so obtrusive in the case of crossed pencils of rays? Again the interferences are unquestionably due to D_1 and D_2 light, simultaneously. If the grids in these two cases should be at a slightly different angle to each other, their superposition would give something like the observed phenomenon apart from details. With white light the linear phenomenon would eventually become achromatic. But why should lines so close together as D_1 and D_2 show any appreciable difference of angle in their interference pattern? Intersecting interference grids, moreover, can be produced by other methods and always betray their origin. The final inference is that suggested by Figs. 4 and 5, that homogeneous rays on crossing (here in a medium of plate glass) may exert a lateral influence on each other, to the effect that identical rays emerging from the crossing are arranged in equidistant nodal planes according to Fig. 4.

Carl Barus

Brown University,
Providence, R. I.

ANNUAL MEETING OF THE CHICAGO ACADEMY OF SCIENCES

On the evening of Tuesday, January 11, the annual meeting of the Chicago Academy of Sciences was held at the Academy building in Lincoln Park, Chicago.

The guest of honor and chief speaker was Director Frederic A. Lucas, of the American Museum of Natural History, and his address was entitled "The Service of the Museum to the Public."

The usual reports were received from the officers of the academy, and the results of the annual election were read. The officers for the ensuing year are: *President*, John M. Coulter; *First Vice-president*, Henry Crew; *Second Vice-president*, Stuart Weller; *Secretary*, Wallace W. Atwood; *Treasurer*, Henry S. Henschen.

Following the business meeting the members and guests were invited to inspect the new exhibit, which extends through the central portion of the main museum floor. It consists of one large case, 75 feet long and 20 feet wide. In this case, and supported from the ceiling, fifty-six of the larger birds of the Chicago region were installed as in flight. The exhibit is viewed from the main floor, and is 8 to 10 feet above the level of the eye, so that the birds are seen much as they might be under fortunate circumstances out-of-doors. One hundred and four habitat groups have now been installed in the Academy Museum to illustrate the natural history of the Chicago region. The birds, flowers, insects, reptiles and mammals are represented, and with the completion of this plan the museum will be unique in America, and have a special educational effectiveness.

Announcement was also made of the following course of open lectures:

February 11. "The Sun" (with illustrations), by Professor Philip Fox, Northwestern University.

February 25. "Liquid Air" (with demonstrations), by Professor Henry Crew, Northwestern University.

March 10. "Radium" (with demonstrations), by Professor H. N. McCoy, University of Chicago.

March 24. "Modern Views of Electricity" (with demonstrations), by Professor R. A. Millikan.

April 7. "Problem of Food Productions" (with illustrations), by Professor John M. Coulter, University of Chicago.

April 21. "Bacteria of the Alimentary Canal" (with illustrations), by Professor A. I. Kendall, Northwestern University.

WALLACE W. ATWOOD,
Secretary

THE ASTRONOMICAL SOCIETY OF THE PACIFIC

AT the annual meeting of the Astronomical Society of the Pacific, held in San Francisco, Saturday, January 29, 1916, the Bruce Gold medal for 1915 was presented to Dr. George Ellery Hale, director of the Solar Observatory (Carnegie Institution), Mt. Wilson, Pasadena, Calif., for distinguished services to astronomy. This medal was founded by Miss Catherine Bruce, of New York, in 1897 with a fund of $2,500, and in the past eighteen years has been awarded to thirteen astronomers.

The following astronomers who have been the recipients of the medal were:

Simon Newcomb, United States.
Arthur Auwers, Germany.
Sir David Gill, England.
Giovanni V. Schiaparelli, Italy.
William Huggins, England.
Hermann Carl Vogel, Germany.
Edward C. Pickering, United States.
George W. Hill, United States.
Jules Henri Poincaré, France.
J. C. Kapteyn, Holland.
O. Blacklund, Russia.
W. W. Campbell, United States.
George E. Hale, United States.

The nominations and the awarding of this medal are probably the most unique in the history of science. Six of the leading observatories in Europe and America, namely, Berlin, Greenwich, Paris, Harvard, Yerkes and Lick Observatories make the nominations. These are sent to the directors of the Astronomical Society of the Pacific, who make the final selection from these nominations for the gold medal.

Professor R. G. Aitken, astronomer, Lick Observatory, in his retiring president's address, paid a tribute to Dr. Hale's work, as a student, director of the Yerkes Observatory and the Solar Observatory, and in the problems of solar physics. The address will be published in full in the publications of the society.

The second address of the evening was given by Dr. H. D. Curtis, Lick Observatory, on the "Recent Theories of Stellar Evolution." This was followed by the election of officers for the ensuing year. *President*, Dr. S. D. Townley, Stanford University; *Vice-president*, C. S. Cushing, San Francisco; *Second Vice-president*, Dr. H. D. Curtis, Lick Observatory; *Third Vice-president*, A. H. Markwart, San Francisco; *Secretary-Treasurer*, D. S. Richardson, San Francisco.

THE BOTANICAL SOCIETY OF AMERICA

THE tenth annual meeting of the Botanical Society of America was held under the auspices of the Ohio State University at Columbus, Ohio, December 27–31, 1915, in affiliation with Section G of the American Association for the Advancement of Science, the American Phytopathological Society and the American Society of Naturalists.

The council for 1916 is as follows:

President—R. A. Harper, Columbia University.

Vice-president—Geo. T. Moore, Missouri Botanical Garden.

Treasurer—Arthur Hollick, Staten Island Association of Arts and Sciences.

Secretary—H. H. Bartlett, University of Michigan.

Councilors—David Fairchild, Bureau of Plant Industry; Wm. F. Ganong, Smith College; B. E. Livingston, The Johns Hopkins University.

One hundred and forty-six new members were elected, and an amendment to the constitution was passed which does away with the grade of "fellow" in the society. The membership of the society is now approximately 500.

The address of Retiring President A. S. Hitchcock, "The Scope and Relations of Taxonomic Botany," followed the *annual dinner for all botanists*, which was attended by 153 members of the affiliating societies. It will be printed in SCIENCE.

The following papers were given by invitation of the council, and will appear in the *American Journal of Botany:*

"The Specificity of Proteins and Starches in relation to Genera, Species and Varieties," by Professor Edw. T. Reichert.

"The Mechanics of Dormancy in Plants," by Professor William Crocker.

"The Periodicity of Freshwater Algæ," by Professor E. N. Transeau.

Joint sessions were held with Section G, American Association for the Advancement of Science and with the American Phytopathological Society, in addition to three general sessions of the society and two sessions of the Physiological Section. The titles and abstracts of the 69 papers follow:

The Bearing of Certain Senile Changes in Plants on Present Theories of Senility: H. M. Benedict.

Present theories of senility are based almost exclusively upon the study of senile degeneration in animal cells and organs.

Now that typical senile degenerations in *Vitis vulpina* and other perennial plants have been shown to occur, senility seems to be more inherently connected with living matter than was formerly supposed to be the case. Theories of senility, if true, must therefore be as applicable to senile degeneration in plants as in animals. The nine more common theories of senility are stated and classified, and examined in the light of the new data obtained from plants. Of these the theory, first advanced by Kassowitz (1899) and supported by Hertwig and Childs, that senility is due to an accumulation of inert catabolic products, is open to the least objection. A suggestion is offered that a more fundamental cause of senility than this may be found in the colloidal constitution of protoplasm with its units in the form of molecular complexes. The tendency, exhibited by certain non-living colloids, of a progressive change toward closer approximation of the molecules constituting the unit, for example, if also occurring in protoplasm would bring about changes in water content, permeability and in other characters which in turn might produce the accumulation of inert or toxic catabolic products.

The Mutual Relations of Host and Parasite in the Genus Gymnosporangium: B. O. Dodge.

It has been previously shown that the leaf form of *Gymnosporangium* on *Chamæcyparis* will infect *Aronia* and *Amelanchier,* giving two different types of æcidia. The galls produced on these hosts are also characteristically different. Later experiments show that different species of *Amelanchier* when infected with the stem form, *Gymnosporangium biseptatum,* develop different types of galls. Variation in the dimensions of the æcidia are also quite marked. This is in line with the results obtained by Long in connection with his experiments with *Puccinia ellisiana* and *P. andropogonis,* and Pammel's observations on the variation in the form of the peridial cells, etc., of *Gymnosporangium macropus* found on different hosts.

What are Chondriosomes? D. M. Mottier.

Argument.—If meristematic tissues of various plants are fixed in a certain mixture of chromosmic acid and sections made therefrom are stained with iron-hematoxylin or crystal violet (Benda's formula), there will be revealed in the majority of cells, in addition to the well-known and familiar cell contents, many small granules, chains of granules or rods of uniform structure but of variable size, that stain blue with crystal violet or black with the iron-hematoxylin. These have been described by various observers as chondriosomes. In the roots of higher plants many of these chondriosomes become leucoplasts, while in the stem they may develop into chloroplasts. Chondriosomes of this nature have been reported from a wide range of families among both higher and lower plants by Guilliermond and others. Different functions have been attributed to these bodies in different plants and in different parts of the same plant. The writer is in harmony with the view that certain so-called chondriosomes become leucoplasts in the root and chloroplasts in the stem. It is argued that in the cells of certain plants examined there are present in addition to these plastids other bodies similar in structure and in reaction to fixing fluids and stains, to the above-mentioned plastids, which do not develop into either leucoplasts or chloroplasts. These bodies are always present in some form (granules or delicate rods) in all cells, reaching a greater development in some cells than in others. They are permanent organs which should be given morphological rank with the nucleus and with the primordia of chloroplasts and leucoplasts. No homology is claimed between the bodies here under consideration and the chondriosomes of animal cells. It is suggested that in function these bodies may be concerned in various ways with the metabolism of the cell, and that, if the cytoplasm is con-

cerned directly with the transmission of hereditary characters, these bodies are to be looked upon as representing hereditary substance. They do not arise from the nucleus. Whether the term chondriosomes should be applied to the organs in question is left an open question.

The Nature of the Cell Plate: C. H. FARR. (Introduced by R. A. HARPER.)

A study of quadripartition of the pollen-mother-cells of a number of dicotyledons, especially *Nicotiana*, in which the cell-division appears to be accomplished without the organization of a cell-plate, but by furrowing as in the division of animal cells. The conditions under which the cells exist were found to approach more closely to those of the typical animal egg than the typical plant cell, namely: the absence of rectilinear cellulose cell-walls; the presence of a mucilaginous matrix, formed by the gelatinization of the walls; the loose disposition in the anther; the spherical form; etc. This suggests a physico-chemical interpretation of the cell-plate, that is, an accumulation of a salt in the equatorial plane between two nuclei. This salt remains in solution if the cell enlarges in response to the osmotic pressure generated by the salt. If, however, the cell can not enlarge either the salt is precipitated or attains such a concentration that the colloids about it are coagulated, thus forming the cell-plate. This conclusion is supported, not only by the present investigation, but by the absence or obscurity of the cell-plate in the algæ and fungi, and by the presence of equatorial structures in many encysted and incrusted animal cells.

The Life-History of Thraustotheca, a Peculiar Water Mold: W. H. WESTON.

In a study of *Thraustotheca clavata* (DeBary) Humphrey, an unusual form hitherto recorded only three times, twice from Germany and once from America, the following facts were ascertained: (1) The process of sporangiospore formation conforms to the usual saprolegniaceous type. (2) The genus is, however, unique among the Saprolegniaceæ in that dehiscence of the sporangium is effected through rupture of the wall as a result of swelling of the non-motile sporangiospores within. The fragility of the sporangium wall, moreover, has been greatly over-emphasized. (3) In their further development the sporangiospores may give rise to zoospores, germ tubes or dwarf sporangia. (4) The zoospores are grooved, laterally bi-ciliate, and of a characteristic shape that can not adequately be described by the terms "reniform" or "bean-shaped" that are generally used in this connection. (5) Gemmæ are formed, but represent merely a transient resting-state induced by unfavorable environmental conditions. (6) In the development of the sexual structures certain phenomena seem to justify the assumption that the formation of antheridia is dependent on contact of the antheridial filaments with the oogonia; and that oospore formation is, under normal circumstances, definitely correlated with the presence of antheridia on the oogonia. (7) In germination the oospores send out hyphæ which either, after limited growth, form sporangia or give rise to extensive mycelia, the type of development depending on the amount of nutriment present. (8) In its structure and development the fungus shows a resemblance to *Achyla* that, in the opinion of the writer, is sufficient to entitle it to a systematic position near the latter genus rather than near *Dictyuchus*.

The Embryogeny of Stangeria: CHARLES J. CHAMBERLAIN.

More than one sperm frequently passes through the neck of the archegonium, but it is extremely rare for more than one to enter the egg. In the metaphase of the first division of the fusion nucleus, only twelve (12) chromosomes, the haploid number, appear; but later divisions show twenty-four (24), the diploid number. Doubtless, the anaphase would show twenty-four (24), as will be described by Hutchinson in a forthcoming paper on *Abies*.

In the earlier free nuclear divisions there is usually a definite polarity, most of the nuclei being in the upper and lower thirds of the proembryo, while the middle third may have no nuclei at all. Toward the close of the free nuclear period all the nuclei in the upper part of the proembryo sometimes divide simultaneously, while those in the lower part remain in the resting condition, so that the nuclei in the upper part become smaller and more numerous than in the lower part. Later, some of the upper nuclei pass to the bottom of the proembryo and, with those already there, divide simultaneously, while those above remain in the resting condition. The embryo is formed from these lower nuclei. During the earlier extra-oval stages, haustorial activity is very prominent.

The Embryo-sac and Embryo of Thismia Americana: NORMA E. PFEIFFER.

Study of this Chicago representative of the Burmanniaceæ shows it to differ from some others of the non-chlorophyllous forms in that the megaspore mother-cell undergoes a reduction division,

giving rise to a row of three cells, the innermost of which functions. A normal eight-celled embryo-sac is found. The pollen has been found to germinate in nature, and probably fertilization occurs, a process not taking place in those forms where there is no reduction. Division of the fertilized egg is preceded by division of the endosperm nucleus. The oldest material available shows an embryo of eight cells, imbedded in conspicuous endosperm cells. The seed shows also the oddly differentiated cells at the chalazal end, as noted by other workers.

The Prothallia of the Cyatheaceæ: ALMA G. STOKEY.

This is a study of fourteen species taken from five of the seven genera of the Cyatheaceæ as given by Engler and Prantl. It includes the supposedly primitive form *Alsophila quadripinnata* C. Chr., also called *Lophosoria pruinata* Pr.

In general appearance the prothallia are of the polypodiaceous type, but in the division Cyatheæ most of the forms have multicellular hairs on both surfaces of the thallus in the anterior region. These hairs are found only on prothallia which have produced archegonia, never on the male prothallia. *Lophosoria* and the five species of the *Dicksoniæ* which were examined do not have multicellular hairs. The antheridia have a basal cell which is usually wedge-shaped; two ring cells, each of which is connected with the outer wall of the antheridium by a lengthwise wall; and two opercular cells, the smaller of which lifts like a valve. The walls, notably those of the stalk and lid cells, are often cutinized. The archegonia are more like those of *Osmunda* than those of *Pteris* and *Adiantum.* They have one or two basal cells; the walls of the neck cells are thickened and are often cutinized; the necks are usually straight. In young archegonia the neck cells have coarsely granular contents, but the neck cells of older archegonia contain a deeply staining mucilage differing somewhat from that produced by the breaking down of the canal cells.

Rapid Methods for Quantitative and Qualitative Studies on the Soil Flora: THOMAS F. MANNS.

The writer since 1901 has spent much time in the study of soil flora. The greatest difficulties encountered have been methods, apparatus and media that would expedite the work. After much experimental work the writer finds the mechanical shaker (run by electric motor) which accommodates sixteen bottles as used for soil analysis, is satisfactory for the preliminary work in properly mixing the sample. With the sixteen containers one may work with the surface samples from sixteen different soils at one time, or he may work with eight samples, including a study of the surface and subsoils. The time required for the plating of 16 soils in duplicate plates with two dilutions on four different media (equivalent to 256 plates) will be from two and one half to three hours. The dilutions will vary according to the groups from 1/1,000 of a gram, to 1/10,000 and 1/100,000 of a gram. The moist sample is prepared very fine and one gram is placed in the eight-ounce bottle (nursing) containing 50 c.c. or 100 c.c. of sterile water. The sample is shaken fifteen minutes. Other dilutions are made from this source.

Usually three media will suffice to bring out the important bacterial groups.

Medium I., for ammonifiers, saprophytic forms including molds, Actinomycetes, etc.

Medium II., for *B. radicicola.*

Medium III., for *Azotobacter, B. radiobacter* and nitrifiers. By means of a constant temperature apparatus, 32 tubes of each of three kinds of media may be kept melted at 43° C. ready for plating. Labelling plates consists in writing soil number, medium number and dilution. For the latter $A = 1/1,000$, $B = 1/10,000$ and $C = 1/100,000$ gram moist soil.

Media for Quantitative and Qualitative Studies on Azotobacter and Nitrifiers (illustrated by cultures): THOMAS F. MANNS.

Several workers, including Winogradsky, Beijerinck, Omelianski, Makrinoff and Löhnis have pointed out the difficulties in culturing nitrogen-fixing and nitrifying bacteria. The same workers and others have shown the importance of certain salts, including the carbonates of magnesium and calcium, also the value of phosphates, certain sugars, soil extracts or humus. Several have shown intimate symbiosis between certain nitrogen-fixing forms such as *B. radiobacter* and *Azotobacter chroococcum.* Löhnis in his "Laboratory Methods in Agricultural Bacteriology," p. 97, has shown the stimulating action of magnesium carbonate and calcium carbonate on the nitrifying bacteria. He states in the same work that "Many different methods have already been tried, but the obtaining of pure cultures of the nitrifying organisms is still a most difficult bacteriological problem. The method which is most to be recommended is the gypsum-magnesium-plating method, proposed by Omelianski and Makrinoff." In reference to *Azo-*

tobacter, he says: "On standard media, it grows only moderately, but, on the contrary, very well on gypsum plates which have been wetted with mannite solution." The writer in making a quantitative survey of the bacteria in various groups of soil organisms, found it necessary to modify and invent new media for the *Azotobacters* and nitrifying organisms; after considerable experimental work it was found that the ingredients of a good *radicicola* or *Azotobacter* medium in a soil extract agar, to which, after tubing was added, about .5 gram of a mixture of insoluble salts, including the carbonates of calcium and magnesium, with kaolin, would bring out the nitrogen-fixing organisms (*Azotobacters, B. radicicola, B. radiobacter*) and the nitrifying organisms (*Nitrosomonas* and *Nitrobacter*). Some of the standard media worked fairly well when balanced by the insoluble minerals. By use of qualitative chemicals the active nitrifying colonies could be easily demonstrated on the plate. These media differ from others in that the insoluble minerals in the tube are shaken up at the time of inoculating and poured into the Petri dish. The studies again emphasize the importance of basic compounds, humus and symbiosis in bringing out *Azotobacter*. The western soils (Colorado, North Dakota) show many *Azotobacter chroococcum*.

Peat Organisms that Slowly Liquefy Agar (illustrated by culture): THOMAS F. MANNS.

While making a study of the flora of raw peat and muck, the writer observed that certain colonies of *bacteria* were able to completely break down the agar and cause deep pitting in the medium. The writer has never met with similar organisms in his extensive culture work on agricultural soils. They are probably quite closely confined to peat and moor soils. Erwin F. Smith mentions in Volume I., "Bacteria in Relation to Plant Disease," p. 32, that "Metcalf has described a bacillus which slowly softens it (agar), and the writer has observed similar phenomena." The organism, which appears to be a micrococcus of about one micron in diameter, was found most abundant in peat that was composted with floats (*ground calcium phosphate*) and *calcium carbonate*, 200 lbs. of each to a ton of the former. The writer has made no extensive morphological, physiological or cultural studies upon the organisms. Note of its occurrence is made here solely from the interest that enzymes of such active properties are produced by bacteria. This agar-digesting organism was grown on the following medium:

	Grams
Mono-potassium-phosphate ($K\,H_2\,PO_4$)...	4.00
Wood ashes (chestnut)	12.00
Ferric sulphate	.25
Mannite	10.00
Agar	12.00
Water	1,000.00

Some Observations on the Occurrence of Sterile Spikelets in Wheat: A. E. GRANTHAM.

The examination of a large number of varieties of wheat grown at the Delaware Agricultural Experiment Station during 1915 indicates that there is considerable variation in the percentage of sterile spikelets per spike among the leading varieties of winter wheat. The study included observations on wheat sown under ordinary field conditions and by the centgener method. It was noted that the varieties grown under field conditions exhibited a higher percentage of sterile spikelets than where the plants were grown 6 inches apart each way as under the centgener method of planting. That is, the thickness of planting appeared to be a factor directly related to the frequency of sterile spikelets. The number of sterile spikelets per spike (the average of 25 spikes for each variety) and the percentage to the whole number of spikelets were determined for 188 varieties of wheat. Of these varieties 80 were beardless and 108 were bearded. The average percentage of sterile spikelets in the bearded varieties was found to be 25.1 per cent., while the beardless averaged 17.8 per cent. This indicates that the bearded varieties, as a class, have a higher percentage of sterile spikelets than the beardless wheats. Only 20 of the 80 varieties of beardless wheats had more than 15 per cent. of sterile spikelets, while not a single variety of bearded wheat had less than 17 per cent. sterile spikelets. Forty-five of the 108 bearded varieties had 25 per cent., or more, sterile spikelets. Of the 80 beardless varieties only 2 had 25 per cent. sterile spikelets. The occurrence of sterile spikelets was also noted on two varieties of wheat (one bearded and the other beardless), when planted at different dates. The two varieties were planted at seven-day intervals from September 17 to October 22, on fertilized and unfertilized soil. The wheat planted at the earlier dates, whether fertilized or not, had a higher percentage of sterile spikelets than the later seeding. In this case, also, the bearded variety had the higher per cent. of sterile spikelets. Two varieties of wheat fertilized with different combinations and quantities of plant food exhibited considerable variation in the number of sterile spikelets. Phosphoric acid and potash used

singly developed a higher per cent. of sterile spikelets than nitrogen, where two of the plant food elements were used in combination. Nitrogen and potash showed the smallest per cent. of sterile spikelets, while phosphoric acid and potash gave the highest. The untreated plots showed a very low per cent. of sterile spikelets, as compared with those receiving complete fertilizers. Correlation studies between the total number of spikelets per spike and the number of sterile spikelets per spike indicate the longer the spike or the more spikelets it carries, the greater the number of sterile spikelets.

Inbreeding in Maize: DONALD F. JONES.

Twelve generations of continuous inbreeding in maize confirm previous conclusions. The reduction in vegetative vigor is rapid at first, but gradually slows down and finally ceases. This reduction in heterosis is correlated with the theoretical approach to complete homozygosity. There is a marked tendency towards complete uniformity within the limits of physiological fluctuation. Accompanying the reduction in variability there is a segregation of characters and an isolation of subvarieties, some having abnormalities. These subvarieties differ in their power for development as expressed by size of plant and yield of grain. After continued inbreeding there is an approach to the stability of a naturally inbred race. The constantly segregating characters in the original cross-bred race are of little value in classification.

The Chlorophyll-factors in Lychnis dioica: GEORGE HARRISON SHULL.

Three Mendelian factors are responsible for the chlorophyll of the normal dark green biotypes of *Lychnis dioica*. One of these factors, Z, differentiates all green strains from albinos, capable only of ephemeral existence. A second factor, N, acting with Z, produces a form with approximately two thirds as much chlorophyll as the normal. The third factor, Y, acts in conjunction with Z and N, to produce the full green color. In the absence of N, Y produces no noticeable effect, for plants with the constitution $XXZZnnYY$ have not been successfully distinguished from those having the formula $XXZZnnyy$, though plants having these two formulæ have now been separated by cultural methods.

Experiments in Recombining Endosperm Colors in Corn: R. A. HARPER.

My work in crossing corns with different colored endosperms has given me results perhaps best described in general as the so-called "breaking up" of characters as understood by the older plant breeders. Well-established and constant black races crossed with white races have given both in the F_1 and the F_2 generations, series of colors including dark purples, reds, blues, grays, etc., in very many shades. Some of these color types are fairly constant, others fluctuate when selfed. During the past summer a series of recombination tests were made to determine whether the ancestral black could be regained by recombining various pairs of these extracted color forms. The results show a further wide range of variation. The largest per cent. of dark kernels was given by a deep olive-gray pollinated by a dark vinaceous purple, but equally dark individual kernels were given by a pale gray or even by white pollinated by the same red. Deep olive-gray pollinated by dark violet gave quite uniform slate grays and grayish blues with tinges of purple. No immediate and uniform return to the ancestral black is obtained by such recombinations so far as yet tested.

Evidences of Hybridism in the Genus Rubus: C. S. HOAR. (Introduced by E. C. JEFFREY.)

The genus *Rubus* in common with other genera of the Rosaceæ has presented a very difficult problem to the systematic botanist. The species described in certain regions, where the genus has been most carefully studied, mount sometimes into the thousands and are often distinguished with the greatest difficulty on account of intergrading forms. Many systematic botanists have consequently been led to the opinion that in this genus hybridism is extremely common under the conditions found in nature. The present communication is for the purpose of making clear that the morphological data are strongly in favor of widespread hybridism in the genus *Rubus*. It has long been recognized that two prominent and often correlated features of hybridism are extreme variability of species and sterility of the reproductive cells (particularly the pollen). A high degree of imperfection is frequently characteristic of the microspores of *Rubus*, especially in those species which overlap in their geographic range and flowering periods. This condition is well illustrated by the highly variable species *Rubus villosus* and *Rubus strigosus* (the probable parent of the Cuthbert raspberry). On the other hand, in *Rubus odoratus*, a species of a high degree of constancy, which flowers long after the mass of *Rubus* species have cast their blossoms, the pollen presents a high condition of perfection. Similar conditions are presented by the interesting species *R. deliciosus*, limited geographically to the Rocky Moun-

tains. In general there is good evidence from the standpoints of extreme variability and correlated gametic sterility of the widespread occurrence of natural hybridism in the genus *Rubus*. The genus accordingly affords one more argument in favor of the view now rapidly gaining ground, that hybridism is at once a prominent cause of variability and the appearance of new species in the Angiosperms.

Pollen Sterility in Relation to the Geographical Distribution of Some Onagraceæ: Carl C. Forsaith. (Presented by E. C. Jeffrey.)

The genus *Œnothera* has been mentioned frequently in communications concerning mutation and hybridization. It seems fitting, therefore, that other genera of the Onagraceæ should be examined for evidences of inter-species crossing. The well-established correlation of pollen sterility and hybridization is considered as a determining factor in this connection. Studies of the *Chamaenerion* subgenus of *Epilobium* presents interesting results. Anthers chosen from the more southern representatives of *Epilobium angustifolium* L. show uniformly potent microspores. Selections of material from stations where this plant is coexistent with its ally, *E. latifolium* L., disclose often abundant abortive pollen grains. The more uniformly distributed group belonging to subgenus Lysimachion, reveals impotent microspores quite generally. The monotypic *Zauschneria californica* Presl. and the geographically limited *Epilobium angustifolium* are seen to present unimpaired fertility. *E. angustifolium,* however, occurring within the territorial limits of *E. latifolium* in North America, manifests microscopic proof of previous cross-fertilization. This feature is in marked contrast to the more uniformly perfect pollen development habitually present in the geographically limited species just mentioned. Thus it is apparent, from the morphological standpoint, that interspecies crossing is a not uncommon occurrence among the Onagraceæ where such is not prevented by kinship or distribution. This interesting fact was first noted by Miss Ruth Holden, of Cambridge, England.

Seed Sterility and Delayed Germination in Œnothera: B. M. Davis.

A study of fifty species, races and hybrids of *Œnothera,* have given surprising data on the extent of seed sterility and delayed germination within this group. The importance of recognizing in genetical work the problems presented by this situation will be discussed and illustrated. A method will be outlined whereby it is hoped that complete germination of seeds may be rapidly forced to completion and at the same time may permit of the preservation for examination of the residue of sterile seed-like structures.

The Production of 14(+)-Chromosome Mutants by 14-Chromosome Œnothera Lamarckiana: Anne M. Lutz.

Gates and Thomas have counted 15 chromosomes in 21 plants variously classified as *Œnothera* mut. *lata, O.* mut. *semilata, O. lata* to *semilata, O.* mut. *lata rubricalyx, O. biennis* mut. *lata* and as *lata*-like forms. Gates had mentioned these results in an earlier paper in 1913 referring to *O.* mut. *lata rubricalyx,* which was found among the F_2 offspring of a cross between two 14-chromosome forms, he says: "The possession of fifteen chromosomes by this plant also shows that whenever a meiotic irregularity leads to the formation of an individual having an extra chromosome, such a plant will have the leaves and habit of *lata* or *semilata.*" Although he adds in a footnote that "it is possible that one or two other mutants also have an extra chromosome," he does not state that such forms are not *lata*-like; furthermore, Gates and Thomas say later "Certain other mutants indicate by their hereditary behavior that they may also have aberrant chromosome numbers, but this has not yet been proved, except in *gigas.*" All of the arguments offered by Gates and Thomas point to the conclusion that whenever a meiotic irregularity in a 14-chromosome form leads to the production of an 8-chromosome gamete, if the latter is capable of functioning, the union of this cell with a 7-chromosome cell will produce *O. lata, O. semilata,* or some *lata*-like form. While many 15-chromosome forms have *lata* or *lata*-like characters, many 15-chromosome mutants, offspring of 14-chromosome forms, are quite unlike *O. lata.* I have counted 15 chromosomes in 11 distinct mutant types: (1) *O. lata,* (2) *O. albida,* (3) *O. bipartita,* (4) type 5,509, supposed to be a modified form of de Vries's *oblonga,* (5) *O. nanella lata,* (6) *O. subovata,* (7) type 2,256, (8) type 4,499, (9) *O. exilis,* (10) *O. exundans,* (11) type 5,365. The first six are produced by *O. Lamarckiana* and other forms—the first four being very common types. Type 2,256 is produced by 14-chromosome *O. nanella,* selfed, type 4,499 by *O. lata,* selfed, and by *O. lata* × *O. Lamarckiana,* while the three remaining mutant types have been observed in cultures of selfed *lata* only, thus far. In addition to the foregoing,

15 chromosomes were counted in a form produced by *Lamarckiana*, bearing a number of characters in common with type 5,509. Fifteen (?) chromosomes were counted in *O. elliptica* (*Lamarckiana* mutant)—number not determined precisely—and in an unnamed mutant from one of de Vries's 1912 cultures of *O. lata* × *O. Lamarckiana*, said to combine the characters of *O. lata* with the smooth, shiny leaves of *O. laeta*. Only 2 of the 11 distinct types in which 15 chromosomes were counted precisely by the writer had *lata* or *lata*-like characters; namely, *O. lata* and *O. nanella lata*. Many other named and unnamed mutant offspring of *O. Lamarckiana* and other 14-chromosome types which can not be designated as *lata*-like forms, indicate by the nature of their somatic characters or hereditary behavior, or both, that they have 15 chromosomes; for example, *O. scintillans*, *O. sublinearis*, *O. leptocarpa*, etc.—mutant offspring of *O. Lamarckiana;* and *O. nanella oblonga*, *O. nanella elliptica*, etc., produced by *O. nanella*. While it is possible that 9- and 6-chromosome gametes, capable of functioning, may be produced by 14-chromosome forms occasionally, that a 9- might unite with a 6-, in rare instances, and produce one of the uncommon types of 15-chromosome mutants, it is probable that most 15-chromosome offspring of 14-chromosome forms, particularly the common types—whether *lata*-like or not—result from 8-7 unions. Of particular interest, in connection with this discussion, is the fact that a *lata*-like mutant appeared in a 1908, and another in a 1910, culture of *Lamarckiana* pollinated by *Lamarckiana*. The two did not duplicate each other nor *O. lata*, and each had 16 instead of 15 chromosomes. They may have arisen from 8-8 or 9-7 unions.

A Comparison of the Wood Structure of Œnothera stenomeres and Its Tetraploid Mutation gigas: W. W. TUPPER AND H. H. BARTLETT.

The change from the $2x$ to $4x$ chromosome number in *O. stenomeres* is concomitant with (1) An increase of 50 per cent. in the length of the vessels, and of 150 per cent. in the area of the cross-section. (2) An increase of 50 per cent. in the length and diameter of the tracheids, corresponding to an increase in volume of 200 per cent. (3) An increase in all three dimensions of the ray cells, but not a proportional increase, resulting in a cell of a different shape with an increase of 275 per cent. in volume. (4) A breaking up of the tall multiple medullary rays into their constituent simple rays

Orthogenetic Saltation in Nephrolepsis: R. C. BENEDICT.

The title, "Orthogenetic Saltations in *Nephrolepsis*," was selected to emphasize two points: First, the variations to be described are discontinuous and of considerable magnitude, *i. e.*, "jumps" or saltations; second, these variations are definitely directed (orthogenetic) along a few distinctly limited lines. The present consideration is purely descriptive. The variations dealt with are all from one variety, *bostoniensis*, of the species, *N. exaltata*. From this variety have come at least three distinct lines of variation, viz., progressive dwarfing, progressive increase in division of leaf, and progressive increase in waviness of leaf. The illustrations to be given are as follows:

Progressive dwarfing: (1) *bostoniensis—Scotti—Wagneri*. (2) *Roosevelti*—Teddy, Jr.,—new form as yet unnamed.

Progressive increase in division of leaf: (1) *bostoniensis—Piersoni—Barrowsi—Whitmani—magnifica*. (2) *Scotti—Scholzeli* (2-pinnate)—*Scholzeli* (3-pinnate).

Progressive increase in waviness of leaf: (1) *exaltata—bostoniensis—Harrisi*—Wm. K. Harris.

Another type of variation, not progressive but retrogressive, is shown in the reversion forms which, however, can not be mentioned in detail here. Finally, two points are to be emphasized. There are at least sixty different sports of *bostoniensis*, nearly all of which may be placed in one of the series mentioned above. These variations are all vegetatively produced.

An Interesting Modification in Xanthium: CHARLES A. SHULL.

A peculiar modification of the burs of *Xanthium* is described, in which the number of the flowers surrounded by the involucre has been greatly increased. In one specimen, a cross section of the bur showed the presence of twenty-six involucral cavities. Twenty-three of the cavities contained the remains of ovarial walls, twelve of which had normally developed seeds, and eleven of which had aborted. Three cavities showed no indications of ovaries, but their position is evidence of their nature. The manner in which this form originated is unknown, but it seems probable that it is either a mutation or a reversion from *X. canadense*. Unfortunately this interesting variety was extinct, so far as the local appearance is concerned, at the time it was received.

H. H. BARTLETT,
Secretary

(*To be continued*)